Delta RMP Steering Committee Meeting

September 23, 2013

1:00 PM – 4:00 PM

Central Valley Regional Water Board

Training Room

11020 Sun Center Drive #200, Rancho Cordova, CA 95670-6114

Call-In Number: 1-877-951-5169; Access code: 949 281 0

WebEx Access:

https://waterboards.webex.com/waterboards/j.php?ED=221899282&UID=501265007&PW=NMWE0ODQ0NzA3&RT=MiM0

Draft Agenda

1.	**Introduce the meeting** Manage expectations: review the agenda and expected outcomes		**1:00** **Brock Bernstein**
2.	**Approve Agenda and Minutes (Attachment)** Review and agree on agenda and action items and approve meeting minutes	Draft Summary 21Aug2013.doc	**1:05** **Brock Bernstein**
3.	**Information: Proposed Resolution for October Board Meeting** Regional Board staff, stormwater representatives, and POTW representatives have collaboratively developed a resolution regarding participation in the Delta RMP in lieu of individual monitoring efforts that is proposed for adoption by the Central Valley Water Board during the October meeting. Its purpose is to commit the Regional Board to modifying permit	Resolution Buff Sheet.doc resolution.doc	**1:10** **Ken Landau**

	monitoring programs and study requirements to aid in the regional evaluation of the Delta and to facilitate the redirection of resources prior to and/or upon amendment of NPDES permits.		
4.	**Action: Oct 10 Panel Discussion** A panel with representatives from other RMPs will be available to discuss the implementation, governance, and participation of their programs. - Expected outcome: Confirm panel format and short-listed panel questions.	priority panel questions.doc	**1:15** **Brock Bernstein** **Thomas Jabusch** **Linda Dorn**
5.	**Decision: Initial Program Operating Entity** The Water Boards have additional funding available to contract with Aquatic Science Center and support the Delta RMP implementation. The contract would need to be developed by October to secure funding. The Delta RMPs governance process and its commitment to transparent decision-making require Steering Committee approval for the choice of a lead operating entity. Expected outcome: Steering Committee decision on whether to approve Aquatic Science Center (ASC) as the lead operating entity for the Delta RMP for the initial implementation phase.	SFEI-ASC Delta work overview.doc	**1:35** **Meghan Sullivan** **Brock Bernstein**

AQUATIC SCIENCE CENTER

7.	**Decision: Initial RMP priorities** The goal is to decide on an initial priority for the RMP that will be used to develop a focused monitoring plan around in support of Delta RMP management questions. TAC chairs will present summary findings and recommendations to inform this discussion. Factsheet leads will briefly summarize factsheet highlights. Expected outcome: determine an initial RMP focus; i.e. decide on the initial priority or identify issues to be resolved to prepare a decision by Oct 10	PDF DeltaRMP-ConstituentPrioritizationInfo.pdf	**2:20** **Brock Bernstein** **Stephen McCord** **Joe Domagalski**
8.	**Plus/Delta, set agenda topics for Oct 10 meeting**		**3:55** **Brock Bernstein**
9.	**Adjourn**		**4:00**

Delta RMP Steering Committee Meeting

August 21, 2013

9:00 AM – 12:00 PM

Sacramento Regional County Sanitation District Building

Sunset Maple Room

10060 Goethe Road, Sacramento, CA 95827

Draft Summary

Attendees:

Voting Steering Committee (and/or Alternate) members present[1]:

Dave Tamayo, Stormwater, Phase I Communities (Sacramento Stormwater Quality Partnership)

Gregg Erickson, Coordinated Monitoring (IEP/CDFW)

Kenneth Landau, Regulatory – State (Central Valley Regional Water Board)

Mike Wackman, Agriculture (San Joaquin County and Delta Water Quality Coalition)

Tim Vendlinski, Regulatory – Federal (U.S. EPA)

Linda Dorn, POTWs (SRCSD)

Tony Pirondini, POTWs (City of Vacaville)

On phone:

Stephanie Reyna-Hiestand, Stormwater, Phase II Communities (City of Tracy)

Stephanie Fong, Alternate-Water Supply (SFCWA)

Val Connor, Water Supply (SFCWA)

Debbie Webster, POTWs (CVCWA)

Others present:

Brock Bernstein, Facilitator

Thomas Jabusch, ASC

Stephen McCord, MEI

[1] *Name, Representation (Affiliation)*

Brian Laurenson, LWA

Meghan Sullivan, Central Valley Regional Water Board

Stephen Clark, Pacific Ecorisk

Rachel Kubiak, Western Plant Health

Patrick Morris, Central Valley Regional Water Board

Jason Lofton, SRCSD

Vyomini Upadhyary, SRCSD

Stephen Clark (Pacific EcoRisk)

Joe Domagalski, USGS

Dalia Fadl, City of Sacramento

On phone:

Karen Ashby, LWA

Casey Wichert, City of Brentwood

1.	**Introductions** Brock Bernstein reviewed the agenda and expected outcomes. A quorum was established. Linda Dorn announced that Jeff Willett retired and the POTWs will announce his replacement on the SC at the next meeting.
2.	**Approval of agenda and minutes** There were no comments on the agenda. The June 4, 2013, meeting minutes were approved.
3.	**Information: Finalized Guiding Principles** Guiding principles have been finalized and approved.
4.	**Information: Permit Workgroup Update** Draft resolution language for the Oct 3-4 Regional Board meeting is now on Pamela Creedon's desk for review. Board meetings will be held in Stockton (Oct 3) and Rancho Cordova (Oct 4). There is no fundamental disagreement on content among the participants of the permit workgroup, which includes representatives of the Regional Water Board, POTWs, and stormwater management agencies. Ken Landau indicated that modifications to POTW permits would be implemented first. At the same time as the discharger permits are being modified to accommodate regional monitoring, the Regional Board staff is also trying to figure

	out whether to issue individual MS4s vs. a regional permit for stormwater. A key question is how many changes can dischargers and regulators absorb at the same time. Dave Tamayo suggested that changes in individual permits would be an impediment to a regional permit. Ken Landau responded that he would make sure that the State Board Phase II language would not withhold the opportunity for in-lieu monitoring through the RMP. Linda Dorn suggested that it would be helpful if the permit workgroup would meet again after the draft permit language is available for review. The draft language will go out to the permit workgroup first, then the SC.
5.	**Action: Panel discussion proposed for Oct Meeting** Following up on a suggestion by the permit workgroup, program staff have invited SC representatives of the Bay RMP and Bight Program to participate in a meeting with the Delta RMP Steering Committee to discuss the implementation, governance, and participation of their programs. Gregg Erickson asked what the expected outcomes are. He suggested that it would be helpful to plan preparing a synopsis of the planned panel discussion that would be posted on the Delta RMP website together with other meeting products. Mike Wackman asked whether any of the invited panelists have any experience with agricultural issues. Brock Bernstein replied that the Bight Program used to look at agricultural issues, although not much agricultural land is left in Southern California. He will talk to Ken Schiff from the Southern California Coastal Water Research Project (SCCWRP), so he can prepare to address this concern to his ability. In the context of SCCWRP, Ken Landau mentioned that he is part of a technical workgroup on CECs that is organized by SCCWRP and will attend a meeting at SCCWRP headquarters next month. <u>Outcomes:</u> - The panel discussion with SC representatives from the San Francisco Bay RMP and Bight Program is scheduled for Oct 10, 10-noon - Delta RMP staff will send out draft panel questions for review - Delta RMP will try to include a panelists who can speak to the agricultural component of regional monitoring
6	**Action: Delta RMP development schedule** Thomas Jabusch reviewed the development schedule of the Delta RMP in relation to expectations set by the Regional Board and the SC, and in the context of the timeline and deliverables of the current ASC contract. The formalizing of participation and organizational arrangements, such as by drafting Memoranda of Agreement (MoAs) or Memoranda of Understanding (MoUs), is one of the elements of the development schedule and ASC contract.

	Dave Tamayo commented that the approach preferred by stormwater management agencies would be that there are no MoAs. The stormwater agencies need permit language to allow for in-lieu participation in the RMP. Gregg Erickson commented that the IEP needs MoUs and adequate time for developing and entering MoUs. An important consideration is that a MoU entered by IEP needs to be implemented in accordance with the IEP budget cycle. Ken Landau suggested that IEP could come aboard in Year 2. Linda Dorn commented that the Regional Board cannot take permittees alone to task as initial participants for Year 1 and if there is a need to do MoAs, it takes the time it takes. The general consensus was that the current scope and timeline for the Delta RMP are ambitious. Ken Landau commented that other programs have started out with focused questions, whereas the Delta RMP is starting out without a well-defined order from the Regional Board and is unfocused in that way. SC members agreed that the scope is to be watched very carefully and that starting out by trying to address the bigger picture questions may not result in a functioning program model. Tim Vendlinski commented that EPA wants to see the Delta RMP aligned with the Delta Science Plana and that the two efforts would be reinforcing each other. Val Connor recommended to go with smaller-scale monitoring but not to forget big-scale thinking. Gregg Erickson commented that he sees the Delta RMP integrating with the IEP, similar to the integration of the Bay RMP with the IEP. Linda Dorn commented that the implementation and coordination with other efforts depends on the program priorities being decided on and that it is difficult to talk about the schedule if the priorities aren't clear. She suggested moving on to discuss the constituent factsheets and what to include in the monitoring. Meghan Sullivan pointed out that the sequence of steps is more important that the timeline per se. Ken Landau added that the Regional Board needs some basis for trust that the RMP is moving towards implementation. The governance structure is one important keystone, but both regulators and the dischargers have agreed on the need to identify additional criteria to be met in the development phase to define progress and at the same time provide a basis for assessing the level and adequacy of participation during the development phase. The current contract with ASC extends through March 2015 and the Regional Board has additional provisional funds ($250,000) available through 2016. These funds would be ideally used for implementing the program and not towards developing the program. The Regional Board is hoping to arrive there by making these funds part of the budget for the first year of implementation. Debbie Webster asked why the State Water Board wouldn’t ask for SWAMP funding for Delta RMP implementation. Meghan Sullivan responded that the Regional Board is hoping to get a budget item for the Delta RMP. Ken Landau added that the Regional Board Executive Management Team hasn’t yet ruled out the possibility of

	using SWAMP funding. There was a mutual understanding among discussion participants that if there was a functioning Delta RMP in place, it would be a higher priority and there would be a better chance of obtaining SWAMP funding. Debbie Webster commented that the sooner the SC will get the priorities in place, the better the chances are to apply for SWAMP funding. Val Connor added that the participants would have to demonstrate to funders and prospective partners that they can implement the Delta RMP. The Regional Board intends to develop a new contract with ASC and is seeking a decision from the SC to reconfirm and approve ASC as the interim lead entity for the program, such that a contract can be developed. The contact scope needs to be developed by October to secure the funds. Thus, a decision is sought on reconfirming ASC as the interim program lead for the initial implementation phase (next 1-3 years). <u>Outcomes:</u> - A decision is sought at the next SC meeting to reconfirm and approve ASC as the interim lead entity for the program, such that a contract can be executed by October. The decision is needed to secure and utilize funding ($250,000) that is provisionally available to the Regional Board toward Delta RMP implementation.
7	**Update: RMP priorities review** The designated leads for each factsheet provided brief overviews of the status and content of each constituent factsheet to obtain initial input and direction from the SC. Linda Dorn noted that the factsheets are in various stages of development, with those being further along that are tied to efforts that have been worked on a lot, such as the pathogens special study and the methylmercury TMDL. She suggested that monitoring that is tied to these efforts would make more sense to take on as an initial priority. Brock Bernstein noted that there is a tradeoff between “adding to an existing package” and “putting own stamp on” RMP activities. Dave Tamayo commented that the pesticides factsheet would need to get away from the idea that all pesticides can be lumped together. He suggested that rather than discussing pesticides globally in one factsheet, it would be preferable to develop specific “white sheets” on pyrethroids or insecticides or other pesticide-related issues where there is a similar body of knowledge. The SC generally agreed that the pesticides factsheet should focus on the question “Is there a problem?” There also was agreement that the discussion of pesticides needs more linkages to existing management programs.

	Mike Wackman commented from a non-technical point of view that the factsheets would need to address the following questions: "What is the problem?" "What can we do about it?" and "What can the RMP do about it?" Or "What is the issue?" and "How do we want to address it?" He emphasized that there need to be links to solving the problem. Linda Dorn suggested that it might make more sense to focus Phase I of the RMP on those topics that seem to be better defined, i.e. methylmercury and Cryptosporidium/Giardia, realizing that nutrients, pesticides, and toxicity might be part of Phase II in the 2nd year of implementation. Dave Tamayo commented that toxicity might be something to move forward on, if more detail is available. Val Connor requested that a summary of facts (content of papers) and guidance (any specific thoughts) be provided to the SC. Recommendations: 1. Make factsheets more concrete at the big-picture level: ⇨ What is the problem? ⇨ What can we do about it? ⇨ What can the RMP do about it? 2. Make linkage between different pieces, i.e. describe what the monitoring looks like if the RMP prioritizes an issue 3. Describe how information is going to be used: ⇨ What is going to happen if we have collected all this information? How is it going to be used toward solving the problem? 4. Some factsheets need to be more specific. For example, the toxicity factsheet needs to include a discussion about the application of toxicity testing in the context of management programs. A table will be useful listing the different types of toxicity tests, sensitivities of testing organisms used, and their applications.
8.	**Next meetings** The next meeting will be on September 23rd at the Central Valley Regional Board (1:00 to 4:00 PM). On Oct 10, there will be an afternoon meeting following a panel discussion with representatives from governing bodies of other RMPs.
	Action items: 9.1. Stephen Clark to draft table compiling available toxicity testing methods and their applications for the toxicity factsheet (due: Aug 27) 9.2. Meghan Sullivan to send draft questions for Oct 10 panel discussion to SC

	for review (due: Aug 30) 9.3. SC to submit questions for Oct 10 panel discussion to Meghan (due: Sep 9) 9.4. Meghan Sullivan to send doodle poll to permit group (due: when sending out draft).

ITEM: 23

SUBJECT: Participation in Delta Regional Monitoring Program In Lieu of Individual Monitoring Efforts

BOARD ACTION: Consideration of Resolution Regarding Participation in Delta Regional Monitoring Program In Lieu of Individual Monitoring Efforts

BACKGROUND: Many agencies and groups monitor water quality, water flows, and ecological conditions in the Bay-Delta, but there is no comprehensive contaminants monitoring and assessment program. The Interagency Ecological Program (IEP), California Department of Water Resources and other organizations, including the Water Boards, conduct some of these analyses, but due to their specific mandates, information gaps may exist. Emerging concerns with contaminants related to the documented decline of pelagic organisms in the Delta, wastewater treatment plant discharges, agricultural discharges, pesticides, blue-green algae toxicity, and unknown toxicity events all highlight the need for a system to coordinate among monitoring programs, integrate contaminants monitoring into existing monitoring efforts, and regularly assess and syntheses collected data.

The Water Boards have made it a priority to develop a Regional Monitoring Program (RMP) for the Delta that not only coordinates monitoring and assessment efforts in and around the Delta, but also regularly gathers, compiles, assesses, and reports data in support of the program. The Delta RMP, like all other regional monitoring efforts, will evolve over time, expanding the scope of issues being studied and the breadth of stakeholder involvement.

The Delta RMP has completed its organizational phase – governance structures are in place, there is an active steering committee, technical committee co-chairs have been appointed, and efforts are in progress to select the first projects for the RMP. The proposed resolution begins to address a critical aspect of future phases – how the RMP will be funded.

In the long term, it is anticipated that funding and in-kind services will come from many sources, including dischargers, agencies managing or modifying the Delta, groups that make beneficial use of Delta waters and habitat, and SWAMP. It is the intent of the Central Valley Water Board to work in concert with the Delta RMP Steering Committee to secure other sources of funding for the program. But the initial funding will come from redirection of funds from dischargers to the RMP, primarily from their current expenditures for individual receiving water monitoring, special studies, and other related activities. The redirected funds will be used by the Steering Committee to develop and implement a more spatially and temporally sound monitoring and study program than currently exists with numerous individual monitoring efforts and continue to support the program over time. The various agencies involved in the RMP will need to evaluate the funding and in-kind services that can be provided to the RMP, and the mechanisms that they will use to provide the funding and in-kind services.

The agencies have asked for a commitment by the Board for the modification of monitoring programs and other permit study requirements to help them evaluate redirection of funds and monitoring efforts into the RMP permits. The proposed resolution provides assurances to the dischargers that the Board will consider modifications to existing permits to allow participation in the Delta Regional Monitoring Program in lieu of individual monitoring efforts.

RECOMMENDATION: Adopt the proposed resolution.

Mgmt. Review____kdl__
Legal Review__________

11020 Sun Center Dr. #200
Rancho Cordova, CA 95670

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

RESOLUTION R5-2013-XXXX

PARTICIPATION IN DELTA REGIONAL MONITORING PROGRAM IN LIEU OF INDIVIDUAL MONITORING EFFORTS

WHEREAS, the California Regional Water Quality Control Board, Central Valley Region (hereinafter Central Valley Water Board), finds that:

1. The Sacramento/San Joaquin Delta (Delta) is an important water supply for municipal, industrial and agricultural use for much of the State, and is a critical ecosystem for fish and wildlife, including many rare and endangered species.

2. Understanding the current conditions within the Delta (water quality and beneficial uses) and the potential impacts to those conditions, is important in order to preserve and enhance the Delta, and provide for corresponding regulatory and management decisions, which should be based upon sound science.

3. Currently, many agencies and organizations are conducting monitoring and data evaluation in the Delta, but there is an overall lack of coordinated monitoring and data evaluation for a variety of reasons. This lack of coordination results in the inability to conduct a regional assessment of the water quality and beneficial use conditions within the Delta, and may result in misdirected expenditure of funds for monitoring and water quality improvements.

4. The Central Valley Water Board requires individual dischargers and discharger groups to conduct monitoring of Delta waters and Delta tributary waters in the vicinity of their discharge, known as ambient (or receiving) water quality monitoring. This monitoring provides information on the impacts of waste discharges on Delta waters, and on the extant condition of the Delta waters. However, the equivalent funds spent on current monitoring efforts could be used more efficiently and productively, and provide a better understanding of geographic and temporal distributions of contaminants and physical conditions in the Delta, and of other Delta water quality issues, if those funds were used for a coordinated ambient monitoring effort, rather than continue to be used in individual, uncoordinated ambient water quality monitoring programs. The Delta Regional Monitoring Program (RMP) will provide data to better inform management and policy decisions regarding the Delta.

5. A Delta RMP is an identified priority in the State Water Resource Control Board's and Central Valley Water Board's Delta Strategic Plan, and a Delta RMP is recommended in the Delta Plan recently adopted by the Delta Stewardship Council.

6. The Delta RMP is a stakeholder effort to provide improved Delta monitoring and data evaluation. The Delta RMP is still being developed, but to date has:
   a. Established a governance structure that includes a Steering Committee consisting of three representatives from Publically Owned Treatment Works, two representatives from Municipal Stormwater Permittees, one representative of Irrigated Agriculture, one representative from Coordinated Monitoring Groups, one representative from Water Supply, one representative from State Regulators, one representative from Federal Regulators, and one representative from the Resource Agencies.
   b. The Aquatic Science Center and Central Valley Water Board staff provide technical and logistical support for the Delta RMP.
   c. The Steering Committee has established its mission, and agreed to goals, objectives and guiding principles.
   d. Technical Advisory Committee (TAC) Co-Chairs have been elected, and candidates recommended for the TAC.
   e. Significant progress has been made in developing and prioritizing constituents for the Delta RMP.

7. The Delta RMP needs secure sources of funding to be viable. The exchange of current and future individual monitoring efforts to the Delta RMP and redirection of funding from those individual efforts is one of the potential funding sources for the Delta RMP.

8. It is the intent of the Central Valley Water Board that the initial costs of Delta RMP participation by permitted dischargers should be relatively "cost neutral," in that financial or in-kind participation in the Delta RMP should be reasonably equivalent to the exchange of costs of discontinued individual monitoring and study efforts. However, it is recognized that new and evolving water quality issues will continue to develop in the Delta, and the costs of Delta RMP participation may increase in the future. It is a continuing goal to be cost neutral for permitted dischargers, even as requirements and costs of continued individual monitoring programs change.

9. It is the intent of the Central Valley Water Board that all waste dischargers with the potential to impact Delta water quality will be encouraged to, and have the flexibility to, participate in the Delta RMP.

10. Other sources of funding beyond permitted dischargers will be required to adequately fund the Delta RMP. Agencies and groups who are not waste dischargers, but use or have an interest in Delta waters, are encouraged to participate in the Delta RMP, including providing funding and/or in lieu services, participating in the Steering or technical advisory committees, and coordinating their separate activities with the Delta RMP.

Therefore be it RESOLVED that:

1. In order to improve the overall coordination of monitoring efforts in the Delta, the Central Valley Water Board intends to modify existing individual and group monitoring programs to allow dischargers to participate in the Delta RMP in lieu of conducting their current individual monitoring efforts.

2. The Central Valley Water Board will consider transferring special studies or other permit requirements from individual permittees to the Delta RMP on a case-by-case basis, and conversely consider accepting studies conducted by the RMP in lieu of requiring studies by individual dischargers.

3. Future Waste Discharge Requirements and NPDES Permits will incorporate flexibility to allow discharger participation as an alternative to individual monitoring programs or studies, as appropriate.

4. Any changes to NPDES Permit monitoring or special study conditions which move monitoring and study responsibility from individual permittees to the Delta RMP must undergo public review and comment, and a public hearing through amendments to NPDES Permits.

5. Participation in the Delta RMP by a Permittee shall consist of providing funds and/or in-kind services to the Delta RMP at least equivalent to discontinued individual monitoring and study efforts. Active participation by discharger representatives on the Delta RMP Steering Committee or technical or other advisory committees that may be formed is encouraged.

6. If a discharger or discharger group fails to maintain adequate participation in the Delta RMP, as determined through criteria to be developed by the Delta RMP Steering Committee, the Steering Committee will recommend to the Central Valley Water Board that an individual monitoring program be reinstated for that discharger or discharger group.

I, PAMELA C. CREEDON, Executive Officer, do hereby certify the foregoing is a true, full, and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, Central Valley Region, on ___________________.

____
PAMELA C. CREEDON, Executive Officer

Governance and Decision-making

1. What was the driver to form the RMP? How did the program evolve?

Funding

2. How is program funding arranged and how has it been negotiated and evolved over time?
3. How do you ensure you get your "money's worth" back from the program?

Implementation

4. How long did it take to get the program on a solid administrative and financial footing?

Participation

5. What were the major hurdles for your constituency to participate and benefit from the program and how have they been overcome?

Coordination

6. How do you coordinate with other monitoring or assessment programs?

Program Operation and Management

7. What is the relationship/interaction between the oversight group (SC), the implementing entity (JPA, consultant, other nonprofit), and staff (Regional Board, consultants)?
8. Are TAC chairs / members paid or not and how is their participation organized and managed?

Data Use

9. How is the data used that is produced by the RMP? Can you provide examples?

Data Analysis and Assessment

10. What happens when participants disagree about interpretation of data analysis / assessment results?

Monitoring

11. How are monitoring locations and frequency selected? Was there any “proving” the location was the right place to monitor?

SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

To: Peter Goodwin, Rainer Hoenicke
From: Meredith Williams
cc: Josh Collins, Jay Davis, Robin Grossinger, Tony Hale, Thomas Jabusch, David Senn
Date: August 2, 2013
Re: SFEI-ASC Ongoing Delta Science

This memo outlines current SFEI-ASC efforts to support science and management of the Delta ecosystem. Over the last several years SFEI-ASC has undertaken many more projects related to the Delta than had historically been the case. Although these projects stemmed from individual requests for our expertise in a range of areas, they have evolved to the point where we have a significant investment in supporting science for the Delta and Central Valley drainages. We've increased our presence in the Delta science community and are developing new relationships and deepening existing ones. The result is that we have a clearer understanding of how we might uniquely contribute to Delta science and management.

Current work
Here is a synopsis of currently active efforts.

Water quality

- Delta RMP: Technical, administrative, and science support for planning and implementing a regional water quality monitoring program for the Sacramento-San Joaquin Delta (Delta RMP). Development of RMP framework largely based on Bay RMP best practices. Establishing a forum for water quality regulators and stakeholders to prioritize and address information needs in support of decision-making. Key partners: CV Water Board, SRCSD, USEPA.

- Bioaccumulation: We lead the state's Bioaccumulation Oversight Group (BOG), a SWAMP/California Water Quality Monitoring Council workgroup. The BOG serves as a forum for coordinating bioaccumulation monitoring throughout California. BOG organized a statewide bioaccumulation symposium (2012) that is now planned to be an annual event. Jay Davis has been lead author for a recent series of statewide surveys on contaminants in sport fish, the most recent of which (May 2013) highlighted Delta methylmercury contamination as a key finding. The BOG is currently developing plans for statewide assessment of cyanotoxins generated by harmful algal blooms. Key partners: State Water Board, Regional Water Boards (including Region 5), USEPA, OEHHA, USGS, USFWS.

- Nutrient science and strategy: Nutrient cycling and loads modeling. Evaluating changes in phytoplankton community composition and the potential role of nutrients in Suisun Bay and the Delta. Synthesis of Suisun and Delta nutrient data and critical review of studies to date related to the role nutrients (including ammonium) play in ecosystem impairment. Note that we serve as the science lead for nutrient science and management strategy for the Bay including development of science plan, monitoring program, community hydrodynamics/water quality/ecological model. Key partners: IEP, Bay RMP.

- Grasslands Bypass Compliance Monitoring support: Science support for ongoing monitoring of impacts of the use of a portion of the San Luis Drain for conveyance of agricultural discharge. Collection and dissemination of data generated by the participating institutions. Responsibilities include results compilation, reporting, and data management. Key partners: USBR, CA DFW, USEPA, USFWS, CV Water Board, USGS.

Wetlands restoration and management

- Tools facilitating landscape-scale restoration in the Sacramento-San Joaquin Delta ecosystem: Development of broadly-supported visions for short- and long-term restoration planning based on an understanding of the geomorphic and ecological processes of the historical landscape, and an analysis of components which persist and may be useful for process-based landscape scale restoration. Development of landscape ecology metrics and conceptual models through an expert science team to identify opportunities to restore gradients of ecological functions and reconnect physical drivers. The goal is to use short-term actions at a site scale that can be strategically linked to maximize long-term resilience – including anticipation of sea level rise. The tools facilitate project prioritization and linkage, setting of local targets and performance measures, visualization of restoration scenarios, and project tracking. Key partners: ERP/DFW, DSP, TNC, UCD.

- Conveyance alternatives analysis and mitigation planning support: Application of standardized tools for assessing the likely effects of the alternative Conveyance Project routes on the distribution, diversity, abundance, and condition of wetlands and related aquatic resources. We are transferring the toolset to DWR and participating in data collection and analysis in preparation for mitigation planning. Key partners: DWR, USEPA, USACE, SWRCB.

- Estuary workgroup participation and support: Representing the Bay Area science community at the Estuary Workgroup to increase the level of integration of Bay and Delta in the products of this workgroup, i.e., the My Water Quality Estuary Portal. Key partners – Broad set of partners per the mandate and implementation of the Water Quality Monitoring Council – SWRCB, IEP, SFCWA, TBI, CA DFW, CA DWR.

Technology and Data Management

- San Francisco Bay Regional Data Center: One of four state RDCs which manage surface water quality data. Operation of the SF RDC to manage a variety of data including but not limited to: sediment and water chemistry, tissue chemistry, wetlands abundance and condition, historical ecology, plus maps and imagery. The SF RDC also develops tools for uploading, accessing, and visualizing data. SFEI is distinct, however, in its emphasis on mapping, GIS, and spatial data management. We are also unique among RDCs in terms of our capacity for applications development – having developed multiple web tools for data delivery, cataloguing, and visualization – all within a spatial context. Extensive experience managing data with rich spatial content (well beyond point data) in support of wetlands protection in particular. We have compiled best-available aquatic resource maps to develop the California Aquatic Resources Inventory (CARI) base map which is now being used in the My Water Quality Wetlands Portal as well as the California EcoAtlas (see below). Key partners: SWRCB – CEDEN and SWAMP, Multiple Wetlands Monitoring Workgroups, SFB RMP and participants, SCCWRP.

- Wetland technology tools for condition, extent, and project tracking: EcoAtlas -Partnered with DRN, SFBJV, and CVJV on a recently awarded EPA proposal to expand content and functionality of EcoAtlas to meet the needs of Delta Restoration Network (DRN) partners. EcoAtlas, an online application, brings together multiple datasets to describe the extent and condition of aquatic resources in support of effective wetland management. Its maps and tools are intended to create a complete picture of aquatic resource in the landscape by integrating stream and wetland maps, restoration information, and monitoring results with land use, transportation, and other information important to aquatic resource planning, permitting, and assessment. Key partners: DRN, SFBJV, CVJV, SWRCB.

- Nutrient data delivery and visualization: Associated with our installation of moored sensors for monitoring in support of nutrient science. Funding is in place to facilitate development of online data download and visualization tools for real-time nutrient monitoring datasets. This will address a long standing need for increased data accessibility. Although initially focused on specific moored sensors, integration with other datasets is likely. For instance, data from the monthly USGS cruises provides more spatially extensive information than the moored sensor data. Key partners: IEP, Bay RMP, USGS.

Core competencies
Within these individual projects are embedded some fundamental operating principles of SFEI-ASC – how we work, what our priorities are, where our strengths lie. Some of these are directly relevant to the Science plan and warrant highlighting here.

Forum
Forum is an Institute-wide Initiative to achieve the levels of consensus, coordination, and collaboration inside and outside the Institute that are required to correctly define aquatic resource problems and to affect enduring solutions. We frequently assemble and host experts who collectively represent broad ranges in technical and policy perspectives to discuss their shared environmental concerns, and to advise and review our programs and projects as well as those of other organizations. The most noted example of this is the Regional Monitoring Program, which is a forum that has fostered a uniquely collaborative relationship among regulators, Bay dischargers, and environmental organizations. This approach is fundamental to how we work. A few additional key examples are:

- Facilitation of workgroups to bring together stakeholders and scientists;
- Convening of technical advisory teams;
- Participation in multiple Water Quality Monitoring Council Workgroups.

Our Forum approach helps us to work across boundaries and barriers – taking multi-disciplinary, integrative approaches.

Science synthesis
Within the last year we have completed scientific syntheses regarding PCB, mercury, nutrients, and emerging contaminants. These syntheses integrate the best available science from multiple sources to prioritize further monitoring and management; identify key areas of study; or apply lessons learned elsewhere to local, regional, or statewide management needs. For instance the mercury synthesis report was coordinated with a larger effort that also examined mercury in the Hudson River Estuary, the Gulf of Mexico, Long Island Sound, Chesapeake Bay, the Gulf of Maine, the Arctic Ocean, and the open ocean to identify the most promising avenues for reducing methylmercury contamination in the Bay Area's aquatic food webs.

In addition, SFEI has developed a scientific focus area designed to cultivate Forum-based approaches between state and local governments and California's 110 Indian Tribes in order to encourage the synthesis of cultural and natural resource planning efforts at a landscape scale. SFEI staff has already engaged tribes in this process via the Tribal Advisory Committee for the CA Water Plan, EPA's Regional Tribal Operation's Committee, and a number of individual tribal governments.

Reuniting the Bay and the Delta
Whenever possible we are encouraging the science and management communities of the Bay and Delta to approach their work in an integrated way that reflects the interdependencies between the Bay and the Delta. We are joining with the San Francisco Estuary Partnership to ensure that the 2015 State of the Estuary report addresses the whole system. In our Nutrient work we are creating a bridge between Bay and Delta nutrient science. We are introducing Bay RMP stakeholders to Delta RMP stakeholders to help them better understand how to structure their program and what the expected benefits may be.

Summary
Our work in the Delta builds on our recognized strengths in: 1) monitoring and applied research, 2) tool/protocol/best practices development, 3) leveraging technology for aquatic science support, and 4) communication. These strengths have direct relevance to many aspects of the Delta Science Plan – particularly those related to applied science and monitoring. . We look forward to further discussions about ways in which these strengths might best be used to support the Delta Science Plan.

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MEMO

To:	Delta Regional Monitoring Program Steering Committee	**Stephen McCord, Ph.D., P.E.** McCord Environmental, Inc. 530-220-3165 sam@mccenv.com
Date:	September 16, 2013 (DRAFT)	
Subject:	Delta RMP Fact Sheets to Prioritize Constituents	**Joseph Domagalski, Ph.D.** US Geological Survey 916-278-3077 joed@usgs.gov

Overview

This memorandum summarizes and synthesizes information gathered from literature and various communications with stakeholders and technical experts on constituents of interest for the Delta Regional Monitoring Program (RMP).

Constituents of Interest

We gathered consistent information for six constituents identified by the Delta RMP Steering Committee as potential prioritizes for monitoring (other lead authors are gratefully acknowledged here as well):

- Current Use Pesticides (Domagalski)
- Methylmercury (McCord)
- Nutrients (Domagalski)
- Pathogens (Brian Laurenson, Larry Walker Assoc.)
- Toxicity (Thomas Jabusch, Aquatic Sci. Ctr.)

The synthesis tables in this memo are each arranged in this same alphabetical order.

The “constituent” Ambient Background Characterization was not summarized in a fact sheet and is still undefined in terms of how NPDES permit monitoring requirements for such characterization studies could be incorporated into the RMP. Therefore, it is not evaluated in this synthesis. Also, the constituents salinity and “constituents of emerging concern” were also considered initial but determined to have a lower priority for the Delta RMP.

Process

The process for developing the fact sheets began with developing a consistent outline—the headers for each section of the fact sheets. Information was initially compiled from various literature sources, then draft fact sheets were distributed to stakeholders identified as interested in (or having an expertise in) a particular constituent. We aimed to provide a consistent level of detail to facilitate comparability. The four authors coordinated throughout the process via periodic emails and phone calls.

Synthesis

In addition to the stand-alone fact sheets, the following summary tables consolidate the most important information and recommend monitoring priorities.

Comparison by Decision Criteria

Each constituent is evaluated against seven decision criteria in **Table 1**. The decision criteria, while in no way binding, represent the major topics of interest that Steering Committee members could use to base their prioritization decision. The ranking scale and values given provide a simplistic means of quantifying each response and the collection of responses. Although the criteria are diverse, they are not weighted towards more important criteria. Less quantitatively, the green shading implies a reason to prioritize that constituent (ranking = 5); yellow shading implies a reason not to prioritize that constituent (ranking = 1 or 2).

Understandably, all five constituents ranked 5 for mutual benefit to stakeholders. Scores for significant water quality issue, policy/regulatory support, and timeliness were generally all high as well. The greatest ranges in ranking values were for available resources and technical challenges. The technical challenges for methylmercury are related to its low concentrations, temporal variability, and multiple matrices. The technical challenges for toxicity are related to the interpretation of "hits" and uncertainty in the assessment of causal factors. Toxicity also had the greatest range in values among the criteria, scoring 1 or 5 for six of the seven criteria.

Pathogens, which have the highest total score, can be addressed through a special study already planned. The other four constituents all scored 25 ±1. [NOTE: These sums may be adjusted upon review and discussion by the Steering Committee, as these initial scores were provided by each fact sheet lead largely independent of the others.]

Relevance and Status Relative to RMP Management Questions

A summary of responses to the RMP core management questions for each constituent is provided in **Table 2**. The information is less useful for prioritizing constituents, but does help by capturing in concise terms how each constituent has been addressed by monitoring to date or could be addressed by a future RMP. Pathogens and toxicity—the two highest ranking constituents in Table 1—here appear to have the least amount of current knowledge. The generally high uncertainty for toxicity is consistent with its low score for technical challenges. Although pathogens are not well characterized, there is no reason for concern and the planned special study should provide sufficient characterization to remove it from the list of constituents of concern in the Delta. Current use pesticides appear to be understood conceptually; however, individual pesticide use changes episodically, seasonally and spatially. Methylmercury and nutrients are likely the two least challenging constituents to address, as their dominant sources, pathways and effects are relatively well understood.

Ancillary Conditions

Two general types of monitoring are being discussed by the Steering Committee:

- **Core / status and trends monitoring:** Done periodically according to calendar dates or seasonal signals, at frequencies and times dependent on the inherent variability of interest for each constituent (e.g., pesticide applications, flood seasons). Cyclical (e.g., once every five years) stratified-randomized sampling could be added.
- **Special studies:** Address specific questions related to specific events or drivers. Such studies could include characterizing sources (i.e., identify, estimate loads, and track downstream), estimating reaction rate constants, and evaluating anomalous events (e.g., droughts, floods, "first-flush" events).

The types of monitoring and relevant ancillary conditions to monitor are summarized in **Table 3**. Pathogens can be addressed unambiguously by the Drinking Water Policy Workgroup's planned special study. All four other constituents could have both status/trends monitoring and special study components.

Tabulating ancillary conditions was intended to provide another point of comparison among the proposed constituents. But effectively, almost all listed ancillary conditions would be useful for almost all constituents. The message from this exercise is that the monitoring program—regardless of the prioritized constituent—should include several field measures and additional sample analytes in order to interpret the constituent data. Furthermore, the baseline monitoring regime will almost certainly need to be enhanced with special studies to quantify the conceptual model, satisfy modeling needs, and adaptively manage the program.

One consideration for the Steering Committee is how to divide funding obligations into fixed costs for core program and variable costs for special studies. However, it seems that the core vs. special study lines will be blurred or at least annually variable. Regardless of which constituent and monitoring type is prioritized, the monitoring design will be assessed annually and adaptively managed. And the annual review of core monitoring could highlight knowledge gaps for special studies to address.

Table 1. Evaluation by decision criteria for each constituent.

Constituent	Evaluation Criteria														Overall Evaluation	
	Mutual Benefits & New Stakeholders		Available Resources		Significant WQ Issue		Model Input		Policy & Regulatory Support		Technical Challenges		Timeliness			
	R	Comments	R	Comments	R	Comments	R	Comments	R	Comments	R	Comments	R	Comments	ΣR	Summary
Current Use Pesticides	5	Agricultural interests, managers of urban stormwater runoff	2	Expensive analyses and large spatial variability	4	Future Delta TMDL for pyrethroid insecticides	2	Risk assessment model needs to be developed. Not currently in place	4	Future TMDL	3	Sampling during high flux period can be challenging.	4	Pyrethroid TMDL to be developed soon	24	
Methylmercury	5	All dischargers to the Delta; add other state & fed agencies	3	Expensive; spatial variability; NPDES requirements	4	#1 listed pollutant; links to BDCP	3	Open Water Workgroup to develop fate & transport model; DWP Workgroup model available; USACE model promising	4	TMDL phase 1; fish monit. in 2025; link to u/s TMDLs	2	MeHg non-conservative; need multiple matrices	4	TMDL phase 1 ends in 2018	25	Data would be useful for Phase 1 TMDL review
Nutrients	5	All dischargers to the Delta; add other state & fed agencies, agricultural interests	4	Laboratory costs are reasonable, a small network of nitrate sensors are in place	4	Concentrations expected to rise	3	Source and transport model (USGS SPARROW) to be published this year. Dynamic SPARROW model could be developed	4	Proposed NNE for Delta	3	Very high spatial variability. Needs to be assessed at flow-monitoring station and in combination with in-situ sensors and laboratory analyses	3	Few signs of nutrient enrichment currently	26	
Pathogens	5	Crypto and Giardia for CVDWP. CVDWP has broad base similar to Delta RMP	4	DWPWG participants will participate	3	Bin levels are focus of Basin Plan Amendment and are all at lowest bin with minor exception. Concerns over future growth and wetland sources increasing.	5	Fate and transport models would be useful as pathogens are not conservative	5	Directly supports Basin Plan Amendment monitoring and surveillance	5	Many new available analytical methods that are not as constrained as existing methods	4	Scheduled per Drinking Water Policy	31	One-time special study from CVDWPWG
Toxicity	5	Presumably, all participants would want to identify and address sources of toxicity and/or 303(d) listings	3	Tox sampling by stormwater and ag could be replaced by Delta RMP. IEP and SWAMP could provide in-kind support	5	Main impetus for initiating the RMP	1	There are no numeric models in place that require toxicity data input.	5	Required to addresss information needs for toxicity response program called for in Water Board's Strategic Workplan	1	A major challenge is having appropriate methods available to detect potential future toxicity impairments	5	Delta ecosystem has been described as being in crisis and toxicity impacts have been implicated as one of the possible cuases for the decline of native species	25	Toxicity is one of the primary water quality concerns in the Delta and has been a main driver for initiating the Delta RMP; RB5 resolution and Bay-Delta Strategic Workplan

R = Ranking scale:

1=not at all

2=to little extent

3=to some extent

4=to a moderate extent

5 =to a large extent

Table 2. Responses to management questions by constituent.

Type	Management Questions	Constituent				
		Current Use Pesticides	Methylmercury	Nutrients	Pathogens	Toxicity
Status and Trends--Is there a problem or are there signs of a problem?	a) Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta?	Potential impairment from pyrethroid insecticides	Long-term COMM impairment	Concentrations expected to increase	No	Delta waterways on 303(d) list for sediment tox and unknown tox
	b) Is the issue/contaminant impairing beneficial uses in subregions of the Delta?	Spatial variability is high; TMDL for pyrethroids will be implemented	Significant spatial variability--higher along margins	Ammonia concentrations may affect algal populations; water residence time may affect sub-regions	No	Yes based on 303(d) listings but no systematic comparisons
	c) Are trends similar or different across different subregions of the Delta?	Trends depend on use and weather patterns.	Slight decline over time in LMB	Trends are dependent on flow patterns; location of point sources	Similar	Unknown--evidence focuses on specific sites or pollutants
Sources, Pathways, Loadings, and Processes--Which contaminant sources and processes are most important to understand and quantify?	a) Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to impacts?	Major tributary inputs especially storm events; Delta agriculture load unknown	Multiple natural and human sources	Multiple sources from urban, agricultural and precipitation (N only). Runoff from peat soils also contribute nutrients	Not known, presumed natural, known but not well quantified anthropogenic sources	High uncertainity of sources; pyrethroids and OPs responsible for most known impacts
	b) What are the relative contributions of each source (e.g., municipal wastewater, atmospheric deposition)?	Agricultural and urban runoff are most important; atmospheric deposition is probably insiginificant.	Human & in-Delta sources are minor; floodplains major	Agriculture is largest source of N and P. Geological sources contributes P; WWTPs are significant sources of various forms of N	Not known	Not known
	c) What are the relative contributions of internal sources (e.g. benthic flux) and sinks to the Delta contaminant budgets?	Internal sources of pesticides are largely uncharacterized.	Delta net sink from photodemeth. & settling	Delta sources are important contributors of N and P because of peat soils.	Not known	Not known
Forecasting Water Quality Under Different Management Scenarios	a) How do ambient water quality conditions respond to different management scenarios?	Not currently being studied. Future pyrethroid TMDL should answer some of this	MeHg control studies in progress	Some studies are in progress, especially with regard to ammonia	Not known	Not known
	b) What contaminant loads can the Delta assimilate without impairment of beneficial uses?	Not known	Need up to 78% load reductions	Unknown, some studies are in progress,	Not known	Not applicable
	c) What is the likelihood that the Delta will be water quality-impaired in the future?	Uncertain because of changes in pesticide use patterns, and economic factors	Highly; need to track source reduction effects	Modeling studies suggest increased inputs to the Delta (30% increase by 2050)	Not expected, but there is a need to identify bin level changes	Highly
Effectiveness Tracking	a) Are water quality conditions improving as a result of management actions such that beneficial uses will be met?	Not known	No	Has not been sufficiently assessed	Not known	Insufficient info to support an answer
	b) Are loadings changing as a result of management actions?	Previous studies have shown decreases in OP insecticide loadings; pyrethroid loadings are expected to decrease because of future TMDL action	Reductions from POTWs and MS4s; future increases from wetlands	Loadings of ammonia will decrease because of teritiary treatment at Sacramento Regional.	Not known	Not applicable

Table 3. Monitoring types and ancillary conditions associated with each constituent.

Constituent	Core / Status & Trends: Locations & Matrices	Core / Status & Trends: Species & Forms	Special Study	Ancillary Conditions: Temp.	pH	Salinity; TDS; Cond.	Redox / DO	Org. C; Chl-a	TSS; turbidity	Ions	Flows
Current Use Pesticides	Major tributaries, selected internal locations	Filtered water, suspended sediment hosted pesticides, bed sediment	Stormwater studies	X	X	X		X	X		Inter-subarea; residence time
Methylmercury	Tributaries; account for 8 Delta subareas; sediment, water, biota	unfiltered inorganic and methyl mercury	Yolo Bypass & Delta simulation models; source control effectiveness studies	X	X	X	X	X	X	sulfate, nitrate	Inter-subarea; residence time
Nutrients	Major tributaries, flow monitoring stations	nitrate, nitrite, organic-N, dissolved and total P	Nutrient processing, isotope characterization of processes	X	X	X	X	X	X	Nutrient species	Inter-subarea; residence time
Pathogens	n/a	n/a	Cryptosporidium and giardia	X	X	X		X	X		
Toxicity	Probabilistic: entire Delta Targeted: (a) Indicator or integrator sites representing u/s & in-Delta sources; (b) Significant sites for aquatic resources	Water and sediment	Man. practice implem. studies; TIEs; source ID	X	X	X	X	?	X	X	?

Regulatory and Non-Regulatory Drivers

Stakeholder group decisions are not often made either by pure consensus or by evaluating a suite of criteria objectively and evenly (as in Table 1). To address this point directly, **Table 4** summarizes the various drivers relevant to various stakeholder categories (read: Steering Committee representative) that could be addressed by the Delta RMP. Green shading implies that that constituent has some import to that category of stakeholder. Consistent with the observation in Table 1 that all constituents appear important to all RMP stakeholders, many cells are shaded. The bottommost two categories, which represent potential new RMP stakeholders, are less frequently shaded.

Table 4. Drivers and constituent categories that could be addressed by the Delta RMP.

Stakeholder Category	Stakeholder & Groups Represented	Interests	Constituents				
			Pesticides	MeHg	Nutrients	Pathogens	Toxicity
POTWs	Municipal & industrial wastewater dischargers	NPDES permit compliance monitoring; SIP RPA; site-specific objectives					
Stormwater, Phase I	Stormwater Managers (Sacramento, Stockton, Contra Costa)	Permit compliance monitoring; site-specific objectives					
Stormwater, Phase II	Stormwater Managers (~12)	Permit compliance monitoring; site-specific objectives					
Agriculture	ILRP WQ Coalitions (DSJWQC, SVWQC, CRC), US Dept. Agriculture, Resource Cons. Dist.	BMP effectiveness; WDR compliance					
Regulatory - State	CA Dept Pesticide Regulation, Regional Board, State Board, SWAMP, Delta Vision, BDCP, CA Dept Fish & Wildlife, Ocean Protection Council	305(b) reports & 303(d) listings; TMDL development					
Regulatory - Federal	US Army Corps of Engineers, USEPA Region IX, USFWS, NOAA-NMFS	305(b) reports & 303(d) listings; TMDL development; permit compliance					
Coordinated Monitoring	Interagency Ecological Program, U.S. Bureau of Recl., CA Dept. Water Res.	POD; BDCP					
Water Supply	Water Purveyors: State Water Contractors, CUWA	Drinking water contaminant tracking and source identification					
	Water managers: SFCWA, DWR-MWQI, USBR	Drinking water contaminant tracking and source identification					
	CA Dept. Health Services	Drinking water contaminants; environmental health					
Regulated, if interested	Reserve Managers: US Fish & Wildlife Service, CA Dep. Fish & Wildlife	Nutrients, toxicity, pesticides, salinity, bioaccumulatives					
	Entities undertaking projects subject to CEQA	CEQA compliance and mitigation monitoring					
	Wetland mitigation banks: Westervelt, Wildlands	Mitigation success monitoring					
	Construction projects	Statewide construction general permit compliance					
	Dredgers: Port of Sacramento, US Army Corps of Engineers	Contaminant transport and transformations					
As needed; project-specific	Integrated Regional Water Management Programs (IRWMPs)	Project effectiveness					
	Local watershed groups	Health of watershed; effect of actions					
	Environmental NGOs: BayKeeper, NRDC, CA Sport-fishing Alliance, Sierra Club, The Nature Conservancy, Ducks Unlimited	Identifying and tracking ambient water quality issues					

RMP Development Schedule

The Steering Committee should aim to initiate monitoring by water year 2014. Timing issues associated with each constituent are shown in **Table 5**. Again, pathogens will be addressed through a discrete two-year study already planned. Methylmercury, current use pesticides, and nutrients all have upcoming regulatory activities. Toxicity does not have a time-specific activity planned, although it is a priority interest for regulators. However, monitoring current use pesticides would be focused on locations and during periods when toxicity has been observed.

Table 5. Timing issues associated with each candidate constituent.

Constituent	Year to Implement							Notes
	2014	2015	2016	2017	2018	2019	2020	
Current Use Pesticides	Pyrethroids TMDL?							
Methylmercury	====== Phase I control studies ===========→							Confirm TMDL baseline from <2005; develop model inputs
		Interim TAC review				TMDL Review		
Nutrients	SF Bay NNE?							
	========= Delta NNE? =================→							
Pathogens		= Study period =>						Two year study following LT2
Toxicity								R5 resol. & Bay-Delta Strategic Workplan; could start in 2014

Next Steps

The next step in the RMP development process is of course for the Steering Committee to identify the prioritized constituent(s). Related directly to that decision, the Steering Committee should also:

- Distinguish between interests in baseline/trend/core monitoring and special studies.
- Clarify the relationship between the RMP and NPDES permit-required background characterization studies.

Next, several related steps will be needed before operating the RMP. We are providing the following recommendations to the Steering Committee for consideration as next steps in the process of developing a working RMP, in approximate chronological order.

- Clarify how RMP representatives (Steering Committee members, project team, TAC members) should interact with other monitoring program staff and stakeholders?
- Identify potential TAC members based on general knowledge of Delta monitoring activities and/or constituent-specific expertise.
- Compile information identifying where general water quality conditions are currently monitored. The same stations will likely be useful for logistical reasons (i.e., easy access) and continuity (insofar as such conditions correlate with monitored constituents).
- Determine how to divide funding obligations into fixed costs for the core program and variable costs for special studies.

September 16, 2013

[still awaiting CVDWPWG final review]

RMP Constituent Prioritization Fact Sheet
~ Pathogen Special Study ~

Lead: Central Valley Drinking Water Policy Workgroup (Workgroup). A subset of the Workgroup prepared and reviewed this fact sheet (see participant table at the end of this document).

This fact sheet is intended to inform decisions by the Delta RMP Steering Committee (SC) about initial assessment targets. Five fact sheets are being produced, one for each potential initial assessment target: methylmercury, nutrients, pathogens, pesticides, and toxicity. Each fact sheet summarizes existing knowledge (and gaps) based on a consistent outline and guidance. Draft and final results will be presented to the SC to support its decision-making process. Secondary purposes include working with stakeholders to compile and assess relevant information, identifying potential TAC members, and developing knowledge for subsequent monitoring program design.

Overview

General Description of Constituent

The Central Valley Regional Water Quality Control Board (Central Valley Water Board) adopted a Basin Plan Amendment to establish a Drinking Water Policy (Policy) to protect source water quality on July 26, 2013. The Policy includes a narrative water quality objective for two pathogens, *Cryptosporidium* and *Giardia*, with associated implementation and monitoring provisions, as well as language addressing other constituents of potential concern to drinking water.[1]

Central Valley Water Board staff developed the Policy based on contributions from the Workgroup, which includes representation from drinking water agencies, publicly owned treatment works (POTWs), municipal stormwater agencies, agricultural interests, California Department of Public Health, California Department of Water Resources, Delta Stewardship Council, USEPA, and other interested parties. The Workgroup prepared a Synthesis report[2] to summarize their activities related to drinking water constituents of concern in the Sacramento-San Joaquin Delta region, which included data compilation, conceptual and computational modeling, source

[1] Central Valley Regional Water Quality Control Board. July 2013.

[2] Central Valley Drinking Water Policy Workgroup. February 21, 2012.

control assessments, and drinking water treatment modeling. Pathogens were not assessed as part of the computational modeling performed by the Workgroup.

The Policy also outlines several monitoring objectives to address data needs in assessing pathogen source contributions and tracking, fate and transport, and organism viability. The policy includes a one-time pathogen special study intended to be performed in coordination with *Cryptosporidium* and *Giardia* sampling that will occur between 2015 and 2017 at drinking water treatment plant intakes as part of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) required sampling.

Pathogens, such as *Cryptosporidium* and *Giardia*, are microorganisms that infect humans and other organisms and are often found in surface water resulting from animal and human fecal matter.[3] There are many species of *Cryptosporidium* and *Giardia* that infect humans with the most prevalent *Cryptosporidium* species being *Cryptosporidium parvum* and *Cryptosporidium hominis*[4] and the most prevalent *Giardia* species affecting humans being *Giardia lamblia*.[5]

Cryptosporidium are single-celled intestinal parasites that are primarily transmitted through the fecal-oral route with infection occurring as a result of the ingestion of oocysts in contaminated food or water. Symptoms of the *Cryptosporidium* disease, cryptosporidiosis, include diarrhea, stomach cramps, upset stomach, and fever. The infectious dose of *Cryptosporidium* is relatively low with infection in 50 percent of subjects reportedly occurring in the range of 9 to 1,042 oocysts.[6] *Cryptosporidium* hosts include humans, cows, goats, sheep, pigs, horses, dogs, cats, rodents, and wild animals. These animals can discharge large numbers of oocysts in the environment, which can be transported to surface waters. Oocysts in surface waters are subject to sedimentation, predation, and inactivation by temperature and solar radiation. Desiccation of soils in arid locales also increases oocysts inactivation.[7]

Giardia is a single-celled parasite that is found in the intestines of many animals and in feces of infected organisms. *Giardia* exists in the environment as a cyst (dormant stage) or as a trophozoite (metabolically active growth stage). *Giardia* is robust and can survive a wide range of temperatures including ambient surface water temperatures and internal animal temperatures. Infection is from the fecal-oral route with a low infectious

[3] USEPA Information Collection Rule – Pathogen Information: http://www.epa.gov/enviro/html/icr/pathogens.html

[4] Centers for Disease Control and Prevention: Parasites – Cryptosporidium: http://www.cdc.gov/parasites/crypto/

[5] Centers for Disease Control and Prevention: Parasites – Giardia: http://www.cdc.gov/parasites/giardia/

[6] Tetra Tech. 2007. p. 2-10.

[7] Tetra Tech. 2007. p. 2-11

dose; a dose of 10 cysts can cause infection. *Giardia* infection symptoms include diarrhea and abdominal pain.[8]

Cryptosporidium and *Giardia* in source waters are of concern to drinking water agencies because source water protection provides the first barrier to public health protection. The levels of *Cryptosporidium* and *Giardia* at drinking water intakes determine the level of removal/inactivation required in water treatment plants, with increasing treatment requirements associated with higher pathogen concentrations. Other pathogenic organisms (e.g., noroviruses) may be of concern, but are not well understood in receiving waters nor specifically regulated by the July 2013 Basin Plan Amendment.

Core Monitoring and Special Study Options

The proposed pathogen study would be a one-time, two year study to satisfy the Basin Plan monitoring and surveillance section July 2013 amendment. Monitoring would be conducted at the same time as the next phase of LT2 monitoring for large systems (>100,000 population served), which is scheduled to begin in April 2015 and end in March 2017. Monitoring could entail:

- Ambient water quality locations where historic data are unavailable;
- Representative discharge locations and effluent categories such as:
    - Wetland areas – managed, natural, treatment,
    - Urban runoff,
    - POTWs – facilities with different treatment levels,
    - Agriculture/farmland animal areas, and
    - Other sources;
- Viability, infectibility, and fate and transport studies;
- Microbial source tracking techniques to better understand sources of observed ambient concentrations; and
- Data collection to improve modeling tools including hydrodynamic and particle tracking models.

It is expected that the Workgroup would design the study plan and the Delta RMP would lead and complete the investigation in coordination with the Workgroup. The Workgroup is well represented within the Delta RMP Steering Committee, if not by individual participants, then by agency, organization, or interest group. However, because of the specific Basin Plan requirements, the Workgroup would actively participate and coordinate with the TAC and Steering Committee.

Summary Statements

Given the significance of the Delta as a drinking water source, improved quantifications and understanding of the loads, fate, and transport of pathogens in and around the Delta is important. Available information indicates that current ambient levels of

[8] Tetra Tech. 2007. p. 2-9

Cryptosporidium and *Giardia* are not adversely affecting drinking water beneficial uses. It is anticipated that performance of the one-time study required in the Drinking Water Policy will resolve concerns regarding future impacts of these pathogens on Delta drinking water beneficial uses.

Available Information and Knowledge Gaps

Brief Synopsis of Readily Available Information

There is limited information available regarding *Cryptosporidium* and *Giardia* specific to the Delta region. In 2007, Tetra Tech developed a *Conceptual Model for Pathogen and Pathogen Indicators in the Central Valley and Sacramento-San Joaquin Delta*, which provided a summary of *Cryptosporidium* and *Giardia* data collected within the Sacramento River and the American River by the Coordinated Monitoring Plan (CMP) from 2001 to 2004 and data collected from Sacramento Regional Wastewater Treatment Plant (SRWTP) effluent from 1997 to 2002. Additionally, other NPDES dischargers have performed characterization and source identification studies including the Sacramento Stormwater Quality Partnership[9] and the City of Vacaville.[10] The Workgroup also compiled a more up-to-date assemblage of available Delta pathogen data from drinking water intakes and other ambient monitoring programs. Summaries of these data can be provided upon request, at the listed source, or on the Central Valley Drinking Water Policy website as part of the Staff Report[11].

Pathogens Data, Sources, Fate and Transport

This section presents a synopsis of the *Giardia* and *Cryptosporidium* monitoring that has been conducted by public water systems and others in the upstream watershed, the Delta, and the State Water Project. The available data are limited spatially and temporally but provide the best available information on the current condition of the watershed. Appendix A contains summaries of the data evaluated for the Policy.

[9] McCaslin, Hope, Ph.D., Larry Walker Associates, Inc. *Microbial Source Tracking and Pathogen Detection in Receiving Waters and Urban Runoff for the Sacramento Stormwater Quality Partnership.* Technical Memorandum to Delia McGrath and Ken Ballard. August 29, 2008.

[10] Olivieri, Adam, Dr. P.H., P.E., et. al., EOA, Inc. Easterly Wastewater Treatment Plant: Monitoring Microbial Pathogens and Conducting Microbial Risk Assessment in Effluent and Receiving Water. Prepared for City of Vacaville. August 2012.

[11] Central Valley Regional Water Quality Control Board. *Amendment To the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins To Establish a Drinking Water Policy for Surface Waters of the Sacramento-San Joaquin Delta and Upstream Tributaries Staff Report.* Appendix C. July 2013 <http://www.waterboards.ca.gov/rwqcb5/water_issues/drinking_water_policy/dwp_2013july_stfrpt_final.pdf>

Status & trends: is there a problem or are there signs of a problem?

Data were collected by a number of drinking water agencies throughout the Sacramento and San Joaquin river watersheds and the Delta to comply with the monitoring requirements of the LT2. As a result, these data showed no detections of *Cryptosporidium* in the upper Sacramento River watershed. However, *Cryptosporidium* levels were slightly elevated in the vicinity of the Sacramento urban area (average levels ranging from 0.019 to 0.058 oocysts/L) and low levels were detected at the Delta drinking water intakes (average levels ranging from 0.000 to 0.008 oocysts/L). The levels in the tributaries of the San Joaquin River were also elevated (average levels ranging from 0.033 to 0.075 oocysts/L) when compared to the Sacramento River watershed. The monitoring data show that *Giardia* was detected more frequently and at higher levels than *Cryptosporidium*. At this time, only three water agencies in the study area are required to provide higher levels of treatment due to the source water levels of *Cryptosporidium*. Based on the available data and bin levels, ambient conditions are currently protective of the drinking water beneficial uses and the new Basin Plan narrative water quality objective; however, a better characterization is necessary to identify and understand sources of potential raw water intake degradation before it can occur and impact drinking water treatment requirements.

Sources, pathways, loadings, and processes: what sources and processes are most important to understand and quantify?

There were limited data on *Cryptosporidium* and *Giardia* levels in effluent from NPDES dischargers available. Data collected by Sacramento Regional County Sanitation District showed that both pathogens were frequently detected in the effluent at levels higher than those in the Sacramento River. Generally, data from the Vacaville Easterly Wastewater Treatment Plant showed a lower frequency of detection and lower average levels of both pathogens compared to available ambient data. Also, Sacramento Stormwater Quality Partnership (urban runoff) pathogen data were below detection levels, however, the study had higher reporting limits and used different test procedures. Studies in other regions have shown the presence of pathogens in urban runoff.[12]

Common sources of *Cryptosporidium* and *Giardia* include: (1) domestic animals, either grazing or in confined animal facilities; (2) wild animals in natural lands; (3) aquatic avian and mammalian species inhabiting surface waters; (4) urban runoff; (5) and wastewater discharge.[13] Pathogens have varying environmental requirements (pH, temperature, oxygen) for survival and die off at differing rates. Many of the pathogens can survive in a range of environmental conditions and can exist in environmentally

[12] Bambic, Dustin, et. al. Quantification of Pathogens and Sources of Microbial Indicators for QMRA in Recreational Waters. Final Report. Water Environmental Research Foundation. 2011.

[13] Tetra Tech. 2007. p. 2-1

resistant life stages as cysts or oocysts.[14] Pathogens may be indirectly deposited to receiving waters via runoff during dry and wet weather. However, when transport times are more than a few days, die off of land-deposited pathogens makes the linkage between pathogen sources and in-stream concentrations difficult to quantitatively characterize.[15]

Effectiveness tracking and Forecasting water quality under different management scenarios

There is common agreement within the Workgroup that current levels of *Cryptosporidium* and *Giardia* are low in the Delta and are not currently impacting drinking water (MUN) beneficial uses. However, additional information is needed to characterize levels in the Sacramento and San Joaquin River watersheds. While implementation of filtration/infiltration best management practices (BMPs) to address urban runoff, ultraviolet disinfection or filtration processes at POTWs and BMPs to reduce the impact from farmland animals such as cows, sheep, pigs, horses may aid in decreasing *Cryptosporidium* and *Giardia* inputs from these sources, it is not known whether these control measures would measurably change ambient concentrations. Source control studies and modeling of future (year 2030) conditions performed by the Workgroup determined that net organic carbon loading decreased with urbanization because of current urban runoff practices and wastewater treatment standards and the conversion of higher organic carbon concentration rural and open lands to urban areas. Due to a lack of data and information about fate and transport, conclusions could not be drawn on the impact of land use changes on pathogens. As a result, it is difficult to correlate *Cryptosporidium* and *Giardia* concentrations in the watershed to management actions without additional information.

To address this uncertainty and in order to prevent future adverse impacts to public water systems, an ambient trigger was included in the Policy and Basin Plan Amendment to provide a mechanism for reacting to future increases in ambient *Cryptosporidium* levels at drinking water intakes, should they occur. The results of the proposed pathogen special study would support the implementation of the trigger mechanism, if and when needed. Data and modeling tools developed as part of this special study that build on previous Workgroup efforts would support an understanding of control measure effectiveness and future conditions for *Cryptosporidium* and *Giardia*.

Knowledge and Water Quality Data Gaps

There are significant data gaps with regards to *Cryptosporidium* and *Giardia* concentrations and loads within the Sacramento and San Joaquin Rivers and the Delta. Much of the ambient data that is available in the watershed has been collected at a limited number of drinking water intakes. Collecting additional data on *Cryptosporidium*

[14] Tetra Tech. 2007. p. 2-3

[15] Tetra Tech. 2007. p. 4-1

and *Giardia* in these water bodies and potential sources such as wetlands and urban runoff, wastewater effluent, farmland animal areas/agriculture as well as at drinking water intakes is necessary to address these data gaps. Data limitations prevented a full watershed-scale quantitative analysis of sources and transport during the development of the Pathogen Conceptual Model. The Basin Plan Amendment recognized that further study of ambient *Cryptosporidium* and *Giardia* levels, fate and transport, viability and linkage to various source types are needed to better evaluate the potential impact on water quality and to determine the impact on drinking water supplies.[16] The Workgroup concluded that a one-time monitoring program and investigation should be coordinated with the Delta Regional Monitoring Program (RMP).[17]

Evaluation by Decision Criteria

How would monitoring this constituent provide a mutual benefit to RMP participants? How would monitoring this constituent attract new stakeholders to participate in funding and/or implementation?

The Delta RMP Steering Committee representation closely matches that of the Workgroup, which is a diverse group of stakeholders encompassing the regulatory and regulated communities, in addition to water supply interests. The intent of the proposed pathogen special study is to develop collaborative science rather than performing individual studies that do not adequately address all significant sources or fate and transport between sources and water intakes. Drinking water agencies are required to monitor ambient pathogen concentrations in the upcoming (2015-2017) two year LT2 monitoring and the Workgroup intends to coordinate with this effort. NPDES dischargers have historical pathogen indicator data that can be difficult to translate to *Cryptosporidium* and *Giardia* contributions and would benefit from a coordinated Delta RMP study as intended by the Workgroup. Regulatory agencies are equally interested in understanding how to better interpret source and ambient data and to develop effective regulatory programs. The regulated agencies are supportive of performing the one-time pathogen investigation through the Delta RMP rather than through individual permit-required studies and drinking water agencies are interested in a study that coordinates with the raw water intake pathogen sampling that they will perform starting in 2015. A coordinated investigation would address these multiple interests. The DWR Municipal Water Quality Investigations (MWQI) Program has not been highly active in the Delta RMP and may become more interested in Delta RMP participation as a result of this study.

[16] Central Valley Drinking Water Policy Workgroup. 2012. *Workgroup Synthesis Report*. February 21, 2012. p. 48

[17] Central Valley Drinking Water Policy Workgroup. 2012. *Workgroup Synthesis Report*. February 21, 2012. p. 49.

How could this constituent be monitored with the pool of available financial and in-kind resources? Is special funding available? What opportunities are there for cost-sharing or leveraging?

The investigation would be coordinated with the 2015-2017 two year LT2 monitoring performed by water agencies that serve communities greater than 100,000. The DWR MWQI Program, funded by the urban State Water Contractors, may provide support to this study by conducting ambient monitoring in the Sacramento River and Delta. If funding through the Delta RMP membership is not feasible, financial and in-kind contributions from those interested members and from members of the regulated community may also be possible. Funding for this special project may also be available from SWAMP funds, Cleanup and Abatement funds, or supplemental environmental project funding, if approved by the State and Regional Water Boards.

How would monitoring this constituent help to address a significant water quality question?

The newly adopted Policy requires performance of a one-time pathogen special study to resolve outstanding questions regarding the impact of sources on ambient concentrations and the potential to cause unacceptable increases in ambient levels at drinking water intakes. It also can provide important information should *Cryptosporidium* and *Giardia* levels rise to levels of concern. Performance of this study in conjunction with LT2 monitoring in the 2015 to 2017 period is anticipated to resolve these remaining questions.

How would monitoring data provide key input to an important modeling tool?

Monitoring data would help to improve hydrodynamic and particle tracking models for the Delta. As non-conservative constituents, pathogens are difficult to model in large scale systems. Currently, downstream water agencies routinely utilize highly conservative models to protect raw water intakes from known spills or other upstream incidents, especially during periods of increased wet weather inputs when pathogens may be mobilized. Improvements to modeling tools through better understanding of fate and transport would better characterize the benefit of source control options and also improve operational assumptions for downstream water agencies.

How would monitoring this constituent support existing and/or future policy/regulatory programs?

The proposed monitoring is highly relevant and supports the upcoming mandatory LT2 monitoring (2015 – 2017) and the new Policy and Basin Plan Amendment established by the Central Valley Water Board. The study would be useful in the future if pathogen concentrations trigger follow-up investigations by the Central Valley Water Board as described in the Basin Plan Amendment. The study would provide supporting source and transport context to the raw water intake data collected for the LT2 monitoring, especially if changes in bin level or the triggers are indicated. The Policy will likely be revisited in the years following the study and this investigation would greatly inform the follow-up work associated with pathogens.

What are the technical challenges to monitoring this constituent?

It is technically feasible to monitor these constituents based on USEPA guidance for sampling *Cryptosporidium* and *Giardia* in Method 1623.1: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. These methods are based on staining and microscopy techniques and have limitations related to viability and infectibility assessments. Regardless, they are the basis for the LT2-based bin classifications. Modifications to this approach have included use of larger sample volumes and other techniques to improve accuracy, especially when working with low concentrations. *Cryptosporidium* infectivity can be assessed by a technique known as the "Foci Detection Method and Most Probable Number Method", or FDM-MPN. However, there is not an analogous method currently available for *Giardia.* Host infection methods can be expensive and rely on infecting mammals. There are other microbial source tracking methodologies (e.g., polymerase chain reaction or PCR) techniques, which examine specific DNA matter that can provide detail on the origin of the pathogens. Partnerships with research labs and bulk analyses may provide cost savings and technical support in interpreting results.

Why is it timely to address this constituent?

It is timely to address these constituents to satisfy the requirements and objectives of the Basin Plan Amendment and to protect source water quality and improve public health protection. The two year LT2 monitoring is already scheduled to begin in 2015, which would allow the Delta RMP to further develop the sampling and analysis plan and secure funding.

Additional Input

Readiness to Proceed

The study objectives and components are already well defined, and the Workgroup has initiated development of a more detailed study work plan that could be turned over to the Delta RMP in the next three to six months. Specific sample collection locations and methodologies have not been developed and may require some input from the Delta RMP TAC and Delta RMP Steering Committee. Sample collection could begin as soon as the study design is finalized and in coordination with the LT2 schedule (2015-2017). Members of the Workgroup have an interest in participating in the study design and implementation to ensure that it meets the Basin Plan requirements and intended objectives.

Ancillary Conditions

Pathogen data collection should at least be paired or coordinated with the following:

- field measurements (temperature, dissolved oxygen, electrical conductivity, pH, and turbidity)
- pathogen indicators
- organic carbon
- solids measurements such as suspended sediment concentration and total suspended solids

Collection of this additional data during the study period would be useful for future modeling efforts and data interpretation. Microbial source tracking (MST) methods and other methods to identify sources should be considered for inclusion in this study.

Environmental Justice Considerations

The potential impacts of pathogen exposure on underserved communities as a result of practices including the use of drinking water, through subsistence fishing, or other recreational contact is relevant to the proposed special study. A better understanding of pathogen mobilization, transport, and viability would improve the state of science and public health planning (e.g., risk advisories) compared to less accurate pathogen indicator techniques that are currently used.

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Contributors

Name	Affiliation	Role [1]
Tom Grovhoug	Larry Walker Associates for SRCSD	Preparer
Brian Laurenson	Larry Walker Associates for SRCSD and Sacramento Stormwater Quality Partnership (SSQP)	Preparer
Lysa Voight	Sacramento Regional County Sanitation District (SRCSD)	Reviewer
Elaine Archibald	Archibald Consulting for California Urban Water Agencies (CUWA)	Reviewer
Debbie Webster	Central Valley Clean Water Agencies (CVCWA)	Reviewer
Jay Simi	Central Valley Regional Water Quality Control Board	Reviewer and Sub-group Coordinator
John Dickey	PlanTierra for California Rice Commission	Reviewer
Lynda Smith	Metropolitan Water Districts of Southern California	Reviewer
Mark Bradley	Delta Stewardship Council	Reviewer

Note: [1] A previous version was distributed to the entire Workgroup and subsequent reviews were performed by specific Workgroup members to refine the original document. Additional Workgroup members may participate in the future.

RMP Constituent Prioritization Fact Sheet
~ Methylmercury ~

Lead: Stephen McCord (McCord Environmental, Inc.)

This fact sheet is intended to inform decisions by the Delta RMP Steering Committee (SC) about initial assessment targets. Five fact sheets are being produced, one for each potential initial assessment target: methylmercury, nutrients, pathogens, pesticides, and toxicity. Each fact sheet summarizes existing knowledge (and gaps) based on a consistent outline and guidance. Draft and final results will be presented to the SC to support its decision-making process. Secondary purposes include working with stakeholders to compile and assess relevant information, identifying potential TAC members, and developing knowledge for subsequent monitoring program design.

Overview

General Description of Constituent

Mercury is a global pollutant with both natural and human sources, nearby and distant sources, and current and legacy sources. Mercury is a toxic metal that has no known beneficial function in multicellular organisms. It is found naturally in solid, liquid, and gaseous forms. In water, inorganic mercury is strongly associated with suspended sediments. Certain bacteria that can proliferate in low-oxygen conditions tend to methylate mercury. Methylmercury (MeHg) is the primary form that bioaccumulates in food webs and is a potent neurotoxin. MeHg is nonconservative, with concentrations in water changing by sediment transport, sediment flux, biouptake, photodemethylation, biological demethylation, external loading, and more, many of which are difficult to monitor and predict. Ambient water column concentrations of inorganic mercury and MeHg are on the order of 10 ng/L and 0.1 ng/L, respectively, while concentrations in sport fish are often 10^7 higher. The Delta MeHg TMDL and associated Basin Plan Amendment (collectively referred to herein as the TMDL) is the primary regulatory driver for addressing this constituent.

Core Monitoring and Special Study Options

- MeHg could be monitored as a special study during a two-year period. It would be most useful to monitor multiple matrices concurrently (sediments, water column, biota) and provide data needed for simulating mercury transport and transformation processes.
- Core monitoring could incorporate most ancillary constituents and measurements from which mercury conditions could be inferred: temperature, pH, organic carbon, suspended solids, redox potential (or dissolved oxygen), and salinity.

Summary Statements

- Ambient monitoring, which is not mandated until 2025, would complement discharge monitoring being conducted by in-Delta sources and would support a proposed mercury modeling effort.
- Monitoring should address the effectiveness of major projects and control measures, and the feasibility of attaining the TMDL targets.

Available Information and Knowledge Gaps

Brief Synopsis of Readily Available Information

Status & trends: is there a problem or are there signs of a problem?

- Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta?
  - Mercury bioaccumulation in fish may impair the designated beneficial use of commercial and sport fishing (COMM).
  - Fish tissue data collected since 1970 in the Delta indicate that mercury levels in fish tissue exceed numeric criteria established for the protection of human and wildlife health and have not changed significantly over time (Davis et al., 2013). These mercury levels also pose a threat to wildlife and threatened and endangered species (WILD) that consume Delta fish.

- Is the issue/contaminant impairing beneficial uses in subregions of the Delta?
  - Significant spatial variations in fish tissue mercury concentrations are observed in the Delta, generally elevated on the periphery and lower in the central Delta (CV-RWQCB, 2010).

- Are trends similar or different across different subregions of the Delta?
  - Delta waterways collectively were first listed as impaired for mercury in 1990 (SWRCB-DWQ, 1990).
  - No trends over time have been observed within any subregions, although earlier data are for large predatory fish with low site fidelity.

Sources, pathways, loadings, and processes: what sources and processes are most important to understand and quantify?

- Which sources, pathways, loadings, and processes contribute most to impacts?
  - Major watershed sources of inorganic mercury include historic mining operations, atmospheric deposition, native soils, and geothermal springs (DTMC, 2002).
  - Seasonal wetlands, particularly flood plains of the Yolo Bypass and Cosumnes River, are a significant source of MeHg in the Delta.
  - Conversion of inorganic mercury to MeHg occurs in low-oxygen environments, such as wetlands, as a byproduct of bacterial reduction of sulfates and iron oxides. MeHg can be lost from the water column through photodemethylation, particle adsorption and settling, and demethylation by bacteria (Alpers et al., 2008).

- Consumption of contaminated, high trophic level fish is the primary route of MeHg exposure for both humans and wildlife (USEPA, 1997a).
- An important linkage to understand is the relationship between various sources (and source control measures) and MeHg levels in fish.

- What are the relative contributions of each source?
  - The Delta MeHg TMDL, which accounted for the Yolo Bypass within the TMDL boundary (**Figure 1a** and **Figure 2a**), tributaries (*excluding* the Yolo Bypass) contributed 58% of the MeHg load.
  - In a Calfed study report, Foe et al. (2008) significantly adjusted the MeHg load estimates for the Delta from those used in the TMDL with more data collected during a relatively wet period and by considering the Yolo Bypass as a *tributary* source. Those adjustments (in particular, but among others) doubled the tributary load estimate and reducing by over 90% the wetland sediment load estimate (**Figure 1b** and **Figure 2b**).
  - The TMDL represents open water as a MeHg source, which does not account for photodemethylation or particle settling as counteracting sinks. The Delta is a net sink for MeHg.
  - *In situ* MeHg production within the Yolo Bypass averaged 40% of the MeHg loading to the Delta from the entire Sacramento Basin (Foe et al., 2008).
  - Over 95% of the inorganic mercury load to the Delta is derived from its watershed.

- What are the relative contributions of internal sources and sinks to the Delta contaminant budgets?
  - MeHg flux from within-Delta sediments is estimated to contribute 36% of the annual MeHg load.
  - The Delta is a sink for incoming sediment and more than half of the MeHg is bound to particulates (Foe et al., 2008).
  - Photodegradation and particle settling combined account for the net loss of MeHg in the Delta's water column (Stephenson and Bonnema, 2008; Gill, 2008a).

Forecasting water quality under different management scenarios

- How do ambient water quality conditions respond to different management scenarios?
  - Although no major management practices have been implemented, various ongoing control studies are being developed and implemented by wastewater utilities, large stormwater utilities, wetland managers, water purveyors, dredgers, and flood control managers. These control studies will quantify the load reductions that could be attained for these sources, but will not individually evaluate the net effect of such load reductions on the Delta.
  - Better numerical models are needed to bridge the gap between management scenarios and fish tissue mercury levels in the Delta.

- What contaminant loads can the Delta assimilate without impairment of beneficial uses?

- Reductions in MeHg loadings needed to meet TMDL fish MeHg targets range from 0% (Central Delta) to 78% (Yolo Bypass). This question will be re-examined at the end of Phase I of the Delta MeHg TMDL (after 2018).

- What is the likelihood that the Delta will be water quality-impaired in the future?
  - Concentrations of mercury in Delta sport fish have not changed over the past 40 years and no significant source reductions are anticipated. Rather, several large-scale wetland restoration and flood management projects are likely to increase MeHg production and subsequently increase MeHg in Delta fish. Therefore, the Delta will likely remain impaired by MeHg in the future.
  - Cleanup efforts for several watershed mercury sources (such as mines, mineral springs, and settling basins) may measurably reduce tributary mercury loadings.

Effectiveness tracking

- Are water quality conditions improving as a result of management actions such that beneficial uses will be attained?
  - Apart from source and treatment controls for stormwater and wastewater utilities, no MeHg sources have been targeted for near-term management actions that would reduce MeHg loadings or in-Delta conditions.
  - Large-scale water management efforts (e.g., Bay Delta Conservation Plan mitigation measures, Central Valley Flood Protection Plan) are likely to increase MeHg levels in the Delta and Yolo Bypass.
  - The adaptive management process (see **Figure 3** below) is expected to result in recommendations for monitoring to quantify expected load reductions of control measures.
- Are loadings changing as a result of management actions?
  - POTWs have significantly reduced influent and effluent THg loads through source control and treatment upgrades (especially filtration and nitrification).
  - Phase I stormwater programs implement Mercury Plans for BMPs, industrial inspections, hazmat collection, and outreach.
  - More frequent inundation of the Yolo Bypass and wetland restoration would likely increase MeHg loadings.

Knowledge Gaps

- Key uncertainties are how to reduce inorganic mercury source loads, how to reduce MeHg flux from sediments without deleterious consequences, and whether the fish tissue mercury TMDL targets are attainable.
- Even though thousands of national and local studies have been performed to determine which factors control mercury methylation, only qualitative prediction of MeHg production and fish tissue levels associated with most actions is currently possible.
- Control studies in progress will reduce these knowledge gaps. Additional monitoring would support the development and use of predictive modeling tools needed to address these knowledge gaps.

- The difference in the sums of all MeHg sources to and sinks in the Delta is ~8% of the sum of source loads (Foe et al., 2008). Uncertainties in each source and sink load estimate vary from 5% (Sacramento River at Freeport) to 20% (Yolo Bypass when not flooded). Substantial season and inter-annual variability in loads is also apparent.

Evaluation by Decision Criteria

How would monitoring this constituent provide a mutual benefit to RMP participants? How would monitoring this constituent attract new stakeholders to participate in funding and/or implementation?

- The RMP would support many stakeholders. The Delta MeHg TMDL identifies numerous MeHg sources in the Delta, including wastewater, stormwater and irrigation tailwater dischargers as well as water purveyors, wetland managers, and flood control programs. These parties have a mutual interest in understanding the (un)attainability of fish tissue targets through various management scenarios.
- The open water workgroup was formed to address requirements in the TMDL for the Department of Water Resources, State Lands Commission, Central Valley Flood Protection Board, US Bureau of Reclamation, and U.S. Army Corps of Engineers to conduct control studies for sediment flux of MeHg. Many of these stakeholders would be new participants in the RMP.

How could this constituent be monitored with the pool of available financial and in-kind resources? Is special funding available? What opportunities are there for cost-sharing or leveraging?

- MeHg laboratory analysis is expensive (~$200/sample). Some cost savings could be gained by analyzing mercury using non-standard methods (pers. comm., P. Halpin, 2013).
- The TMDL divides the Delta into eight subareas (**Figure 4**), so monitoring sites would need to characterize each of those. Monitoring multiple matrices (e.g., water, sediment, and fish tissue) and forms (e.g., inorganic and methyl; whole and filtered samples, reactive) mercury along with ancillary conditions useful for interpreting the data (e.g., suspended solids, dissolved oxygen, organic carbon, sulfate) would further increase monitoring costs.
- Most NPDES wastewater dischargers are currently required to conduct ambient background characterization monitoring which will monitor inorganic mercury and MeHg upstream of each outfall. No special funding for MeHg monitoring is currently available.
- Some cost-sharing could be gained by partnering with project site proponents monitoring locally according to their permits, CEQA mitigation measures, or grant scopes of work.

How would monitoring this constituent help to address a significant water quality question?

- The key question is whether source controls by in-Delta dischargers (in the broadest use of the term, consistent with the TMDL) can individually meet their TMDL allocations or collectively attain the TMDL target levels for fish tissue (Windham-Myers and Jabusch 2010).
- Mercury is a broad watershed issue, with legacy and natural mercury sources in both the Coast Range and the Sierra Nevada and impairments throughout the Delta's watershed. Based on the 2010 303(d) report, mercury is the most commonly listed pollutant impairing water bodies in the Central Valley region.
- BDCP conservation measures are likely to increase source loads.

How would monitoring data provide key input to an important modeling tool?

- A mercury simulation model would be useful for highlighting critical mercury sources, tracking effects of restoration and water management projects, and developing a watershed-wide trading program.
- The Open Water Workgroup has proposed to develop and apply a MeHg submodel, which would build upon hydrodynamic models of the Yolo Bypass (under development) and Delta (existing DSM-II).
- The Central Valley Drinking Water Policy Workgroup has developed a suite of modeling tools CALSIM, WARMF, and DSM-II) that could incorporate an inorganic mercury submodel for the Delta, the Sacramento and San Joaquin rivers, and their watersheds downstream of major dams.
- Researchers have applied Delta hydrodynamic (RMA-2) and particle tracking (RMATRK) models to estimate MeHg loss rates in the Delta (Stephenson et al., 2008).
- A US Army Corps of Engineers contractor is developing a model using Environmental Fluid Dynamics Code to track sediments and pollutants through the Delta, extending over 1300 square miles with about 20,000 grid cells. The model has been linked in other projects with ecological models to describe the interaction of flows, salinity, sediment and other water quality conditions on fisheries and other ecological resources.

How would monitoring this constituent support existing and/or future policy/regulatory programs?

- It is relevant to the existing Delta MeHg TMDL. Phase I of the current plan requires dischargers to conduct control studies now through 2018. The Regional Board will review the attainability of the TMDL's allocations and targets after 2018. More data and analyses are needed to evaluate attainability.
- The current TMDL is based on data collected up to 2005. The TMDL calls for monitoring fish in 2025.
- Knowledge gained about mercury transport and transformations would support other TMDLs and projects in the Central Valley.

What are the technical challenges to monitoring this constituent?

- Standard sampling and analytical methods are available for monitoring mercury in its main forms and matrices at appropriate detection limits.
- Sampling and analysis challenges include collecting representative samples using ultra-clean methods and processing samples efficiently. For example, MeHg samples must be acid-preserved within 48 hours of sampling).
- Monitoring design is challenged by MeHg's nonconservative nature (e.g., diurnal variability, high affinity to organic matter).
- Need data in multiple matrices (sediments, water, biota) for clear understanding.

Why is it timely to address this constituent?

- Many RMP stakeholders in the Delta will be conducting control studies, reducing loadings where possible, and monitoring discharges through 2018.
- The Open Water Workgroup's simulation model, which could link source load reductions to fish tissue reductions, will need calibration data by ~2014.
- Ambient data and modeling results would be useful for re-examining and revising the TMDL approach after 2018.

Additional Input

Readiness to Proceed

- Need to clarify mercury simulation model input and calibration needs.
- Monitoring program design expertise is available.

Ancillary Conditions

- Important water quality constituents driving MeHg production, loss, or bioaccumulation include temperature, pH, organic carbon, suspended solids, redox potential (or dissolved oxygen), salinity, nitrate and sulfate.
- Flow rate is important for estimating loads. Residence time may be a related factor in MeHg transformations.

Environmental Justice Considerations

- Members of disadvantaged communities in the Delta region catch and consume Delta fish in disproportionately high numbers (Shilling et al., 2010).
- The TMDL requires in-Delta dischargers to participate in a Mercury Exposure Reduction Program (MERP). The objective of the MERP is to reduce mercury exposure for Delta fish consumers.
- A fish consumption survey conducted by University of California Davis researchers found that Delta-region residents, especially low-income and certain ethnic groups, catch and consume fish from the Delta despite knowledge of fish advisories (Shilling et al., 2010). Telling people to change their habits and eat less or different fish appeared ineffective.
- The State Water Board has contracted with UC Davis researcher Fraser Shilling to survey Native American communities statewide to quantify their fish consumption rates.

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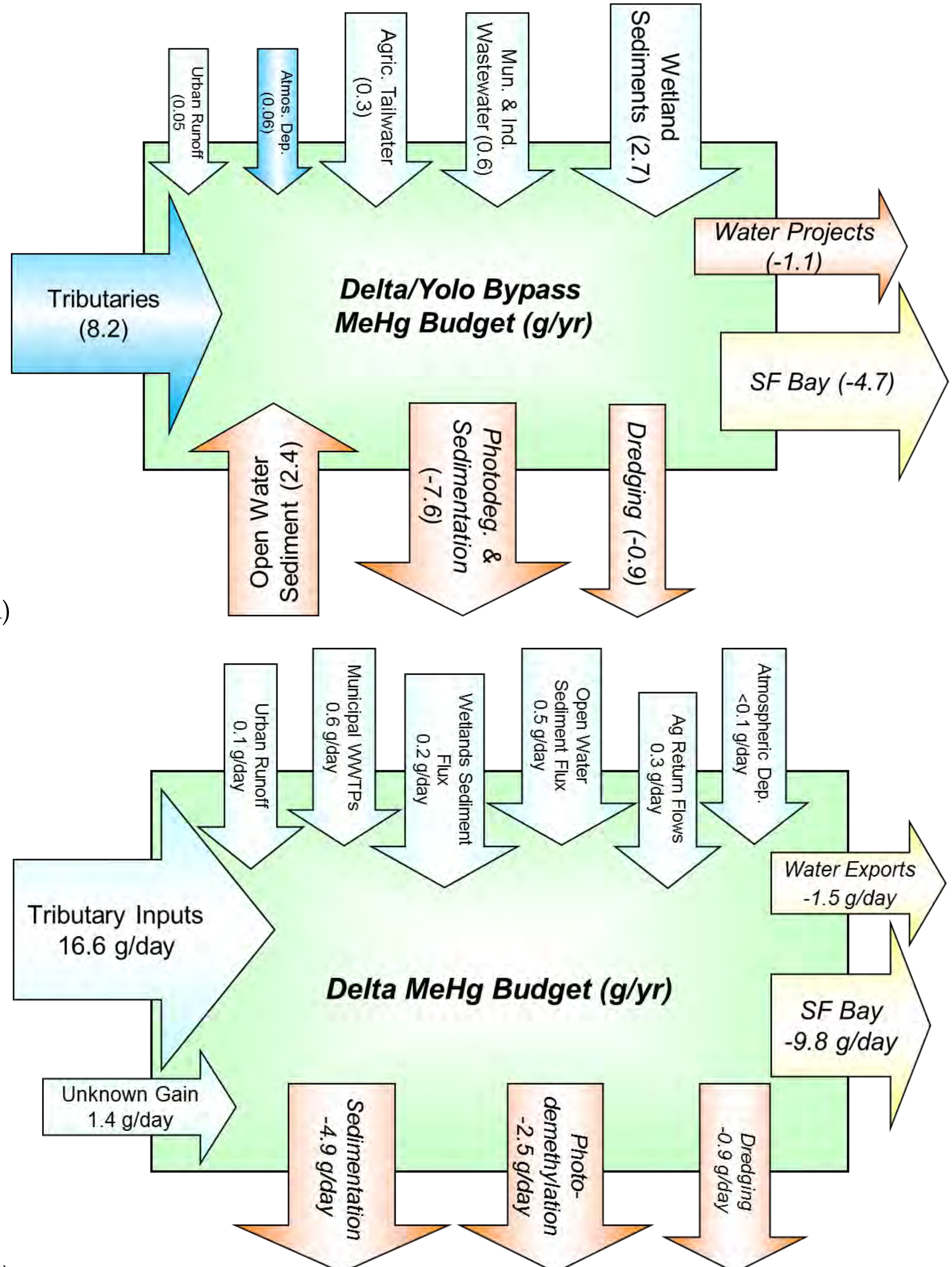
Contributors

- Stephen Louie, Janis Cooke, and Jelena Hartman (Regional Water Board)

- Thomas Jabusch (Aquatic Science Center)
- JR Flanders (URS)
- Lysa Voight (Sacramento Regional County Sanitation District)
- Tom Grovhoug (Larry Walker Associates)
- Tony Pirondini (City of Vacaville)
- Debbie Webster (Central Valley Clean Water Association)
- Bryan Bemis (Applied Marine Sciences)
- Mark Stephenson (Moss Landing Marine Labs)

Figures

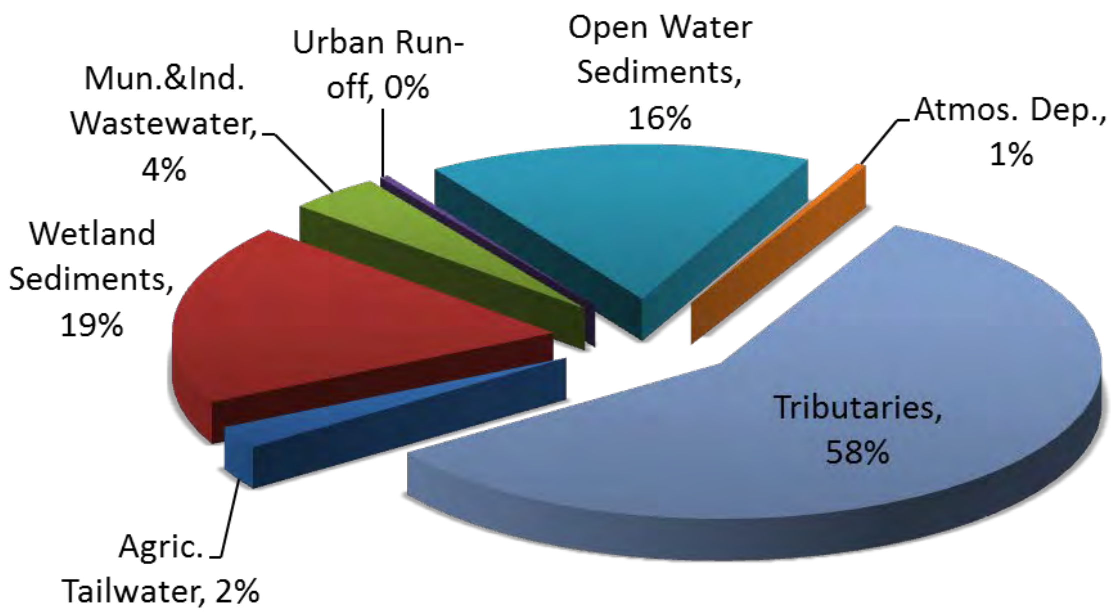


a)

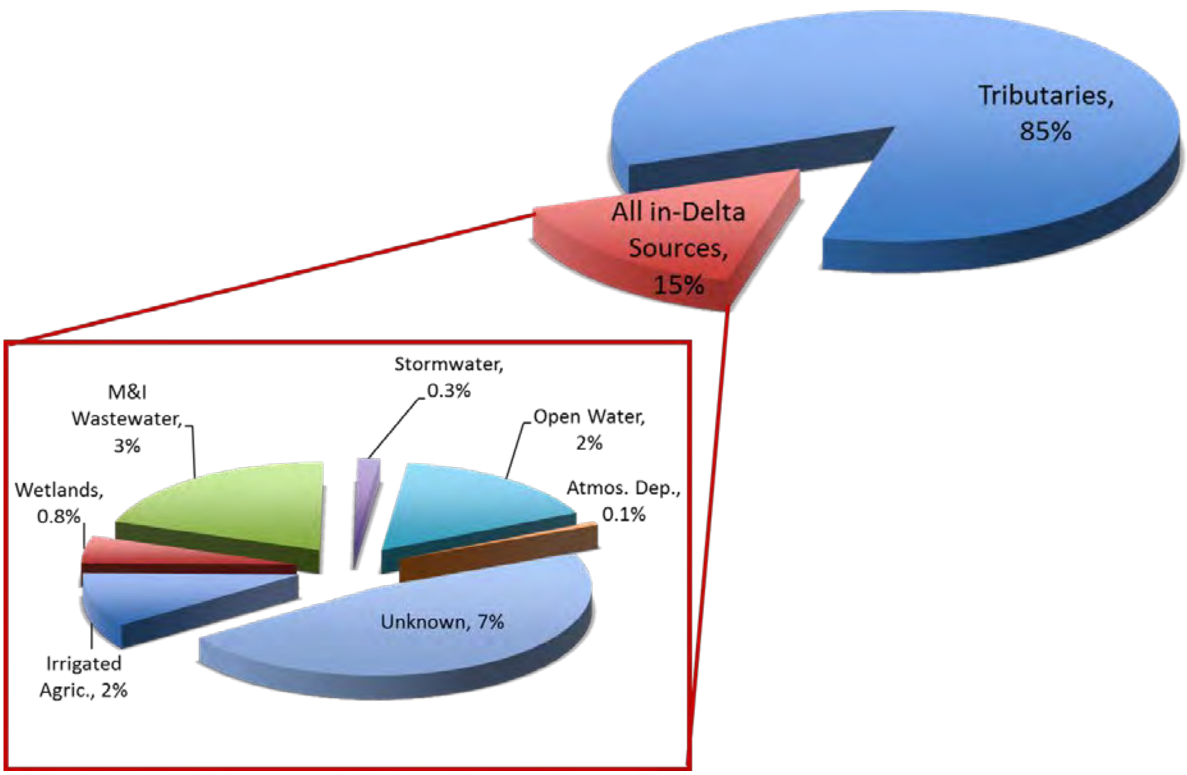
b)

Figure 1. MeHg load balances for the Delta a) per the Delta MeHg TMDL including the Yolo Bypass and b) per Foe et al. (2008) considering the Yolo Bypass a tributary. Losses are written in

italics with arrows outwards; inputs are shaded blue; open water sinks are shaded brown; flood control is an unquantified component of wetland sediments.



a)



b)

Figure 2. Distribution of MeHg source loads among sources to the Delta a) per the Delta MeHg TMDL and b) per Foe et al. (2008). MeHg sinks are not shown.

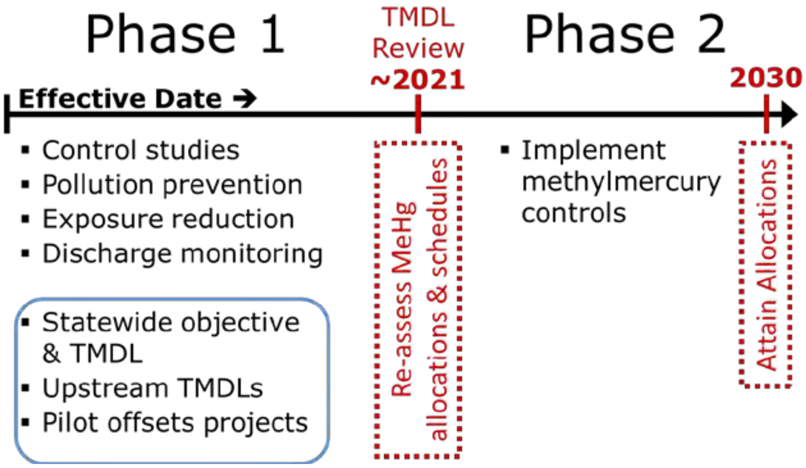


Figure 3. Phased, adaptive management approach in the Delta Methylmercury TMDL implementation plan identifying key requirements and milestones. The three boxed bullet points are related—but not required—regulatory efforts.

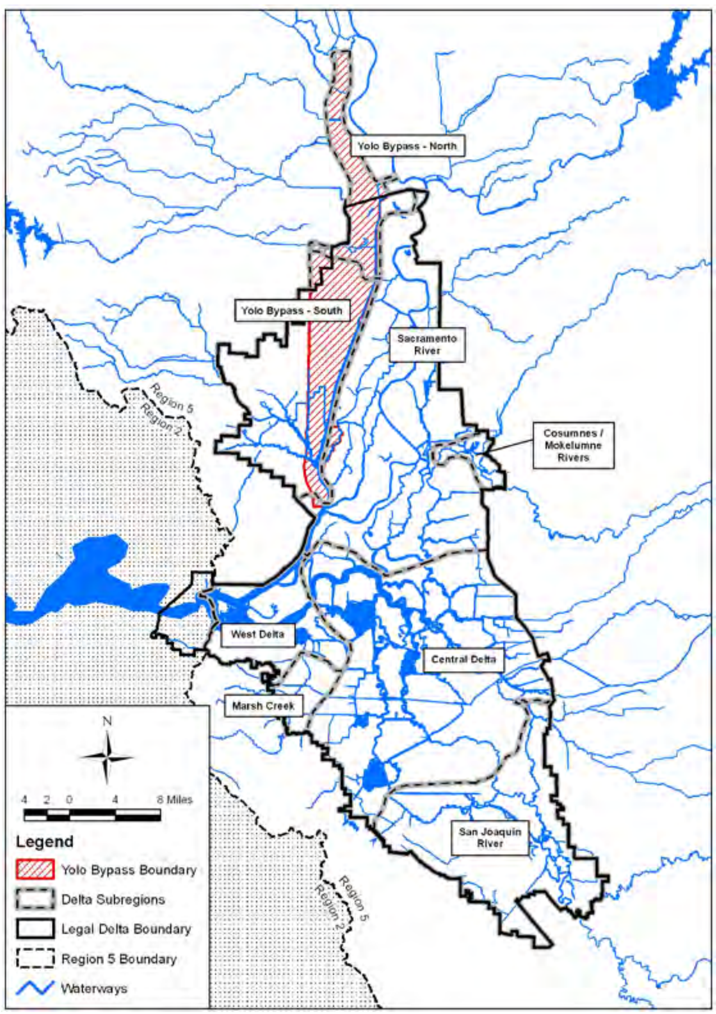


Figure 4. Subareas for the Delta MeHg Control Program.

RMP Constituent Prioritization Fact Sheet

~ Nutrients ~

This fact sheet is intended to inform decisions by the Delta RMP Steering Committee (SC) about initial assessment targets. Five fact sheets are being produced, one for each potential initial assessment target: methylmercury, nutrients, pathogens, pesticides, and toxicity. Each fact sheet summarizes existing knowledge (and gaps) based on a consistent outline and guidance. Draft and final results will be presented to the SC to support its decision-making process. Secondary purposes include working with stakeholders to compile and assess relevant information, identifying potential TAC members, and developing knowledge for subsequent monitoring program design.

General Description of Constituent

Nutrients represent here a class of compounds that include nitrogen (N) and phosphorus (P) in a variety of dissolved and particulate forms. Growth of algae and plants is often limited in most aquatic systems by either N or P, but other nutrients may limit growth. These might include silica, potassium, iron, manganese, magnesium calcium, iron, and other metals. While not a nutrient, light can also be a resource that limits algal growth, and is, for example, thought to be the major limitation on algal growth during much of the year in areas of San Francisco Bay and the Delta due to its highly turbid waters.

All forms of nitrogen are collectively referred to as total nitrogen (TN). Total dissolved forms of nitrogen (TDN) are believed to be the most biologically available. TDN is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia and ammonium (NH_3, NH_4^+), and organic-N. Urea is a form of organic N that is often used as fertilizer but rarely measured in environmental samples. Nitrate and ammonia are the most bioavailable forms of TDN. Organic-N is present in both dissolved and particulate forms and, in general, has to be mineralized to nitrate or ammonium before it is bioavailable. Natural river systems tend to have mostly organic forms of nitrogen whereas systems that are loaded with nitrogen from fertilizers or human and animal waste can sometimes have excessive dissolved nitrogen in the from of nitrate and ammonium.

The sum of all forms of phosphorus are referred to as total phosphorus (TP). TP includes phosphate (PO_4^{3-}), which is referred to as orthophosphate when dissolved, and various forms that are associated with particles. A substantial fraction of phosphorus in the natural riverine environment can be attached to particulate matter. Systems that are loaded with phosphorus from fertilizers or human and animal waste can sometimes have excessive phosphorus.

A common response in aquatic systems that experience an increase in bioavailable concentrations of nutrients is for pelagic primary productivity, and possibly invasive plant species, to increase. Nitrogen enters aquatic systems through runoff from land sources, direct inputs of groundwater, atmospheric deposition, and nitrogen fixation, whereas phosphorus enters water bodies primarily from runoff from land surfaces, untreated wastes, and point sources. Some geologic formations and soils can provide a natural source through weathering and soil forming processes. Under natural conditions, nutrient loads to surface water, and associated concentrations, depend on processes occurring in the watershed. Human activities can increase nutrient loads, especially in wastewater discharges and runoff from agricultural and urban lands. Excess nutrient loads (i.e. eutrophication) can stimulate excessive algal growth leading to undesirable conditions such as oxygen depletion.

In general, freshwater aquatic systems tend to be limited by phosphorus while marine systems are more often limited by nitrogen and other elements. Estuarine waters are more complicated and generalizations about nutrient limitation cannot be made. In addition, recent research has hypothesized that an excess of a particular type of nutrient, such as ammonia, may lead to changes in the type of algae in a river or estuary, which may have subsequent effects on food chain processes. A thorough understanding of nutrients sources within a watershed and transport to receiving waters is necessary for effective management. For example, the Delta Stewardship Council in the Delta has hypothesized that elevated nutrients may cause four specific impairments. These include excessive growth of macrophytes and blue-green algae, low levels of oxygen in back sloughs in the eastern and southern delta, and a shift in algal species composition from diatoms to flagellates and blue-greens.

Organic carbon is related to nutrients in that highly productive aquatic systems have elevated carbon levels. From a regulatory perspective, organic carbon compounds can affect drinking water treatment requirements under the Safe Drinking Water Act. Trihalomethanes are formed in drinking water treatment through a reaction between organic carbon, both DOC and POC, and chlorine used for disinfection. The US EPA regulates drinking water treatment systems depending on the organic carbon levels present in raw source waters to avoid creation of unacceptable levels of trihalomethanes in tap water. In the Delta, this issue has been fully evaluated by the Drinking Water Policy work group, which has determined that current and projected future levels of organic carbon in the Delta are not anticipated to cause additional regulation of drinking water treatment agencies under the SDWA (Central Valley RWQCB website, Drinking Water, Basin Plan amendment and staff report dated 2013; also workgroup Synthesis report dated 2012). However, high levels of organic matter can also translate into high biological oxygen demand, which can lead to low dissolved oxygen.

Core Monitoring and Special Study Options

Nutrient monitoring should include the forms of nitrogen and phosphorus discussed above (NO_3^-, NO_2^-, NH_3/NH_4^+, organic-N, PO_4^{3-}, particulate-P). These forms should be part of a core monitoring approach for routine sample collection. Because of tidal movement of water in the Delta, the monitoring of nutrients should be focused at locations where flow measurements are being collected. Furthermore, there is known spatial and temporal variability in nutrient concentrations (see Figure 2 for temporal variability at Cache Slough for phosphate, nitrate and chlorophyll-*a*). There are currently about 5 locations in the Delta where continuous monitoring of nitrate and/or organic carbon is taking place. Funding is already expected for at least two more locations. Nitrate only represents a fraction of the total amount of nitrogen present and Delta islands release a substantial portion of organic nitrogen. Routinely collected samples for the above species in addition to special studies, such as isotopes of nitrogen that will help in the understanding of nutrient processing, is recommended.

Summary Statements

Nutrient inputs to the Delta will increase as indicated by recent forecasting modeling studies. In addition, new infrastructure for water transfer in the Delta and infrastructure to existing wastewater treatment facilities will change the residence time of water in portions of the Delta, and change the types of nutrient species transported to the Delta. Monitoring of nutrients in relation to flow conditions and ecosystem processes is necessary to formulate management decisions.

Available Information and Knowledge Gaps

Brief synopsis of readily available information

Status & trends: is there a problem or are there signs of a problem? Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta?

- There is an indication of an upward trend in TN from the San Joaquin River, but the Sacramento River has shown a downward trend, at least for the time frame of the study (1975-2004) (Kratzer et al., 2011). TP has not shown any significant trends in either basin. These studies focused on steady state conditions, and the effects of high stream flow on nutrient loads is less well known.
- Long-term monitoring of algal processes in the Delta and San Francisco Bay (Cloern et al., 1996, 1999, 2001) have shown that algal productivity is light limited, which limits productivity in spite of high nutrient loading. However, water has been getting clearer since 1999 and the availability of light is thought

to be less of a limitation on plant and algal growth in Suisun Bay and the Delta (Schoellhamer 2011). However, large scale changes in Delta water management, such as diversion tunnels will change the primary source of water in the Delta, resulting in incrased water residence times in the south and central Delta. This could change algal biomass and species composition.

- Some recent studies have suggested that ammonia loading from wastewater plants affect the Delta by causing a change in the type of algae that are dominant during certain time frames or decrease overall productivity (Dugdale, 2007, Glibert, 2010,Parker et al., 2011; Pulse of the Delta, 2012, Senn et al., 2013). This can potentially cause changes in fish communities as their food webs might change. However, these hypotheses, and the potential importance of these mechanisms relative to other factors that influence production and food webs, remain controversial
- Modeling studies suggest a 30% increase in total nitrogen loading from the Sacramento and San Joaquin Rivers by the year 2050 (Bergamaschii et al., 2012).

Is the issue/contaminant impairing beneficial uses in subregions of the Delta?

-
- There are locally important regions where excess nutrients, in combination with hydrodynamic and other factors, have led to decreases in dissolved oxygen, such as the Stockton Deep Water Ship Channel (Newcomb and Pierce, 2010). There are 13 waterways currently on the 303(d) list for dissolved oxygen. Elevated nutrient concentrations may contribute to each impairment
- There is some information that other portions of the Delta may have excess algal growth, which may be due to increased inputs from tributary streams, or increased runoff from Delta islands, although further monitoring is needed to fully understand this (Lehman et al., 2005, 2008).
- [Chris Foe would likely have helpful suggestions on macrophytes. I personally don't know the extent to which those can be directly linked to increased nutrient loads, though]

Are trends similar or different across different subregions of the Delta?

- Most previously published studies have suggested that nutrients are not currently having an overall adverse effect on the Delta, with respect to eutrophication, but that continued monitoring is necessary if loadings increase from land use changes, agricultural practices, and climate change decrease from wastewater discharges. Technical reports prepared for the Drinking Water Policy work group (Central Valley RWQCB website) do not predict that nutrient loadings will increase in the future, using 2035 as a planning horizon, but continued monitoring is necessary to determine if those predictions are correct.

- The Delta Stewardship Council has suggested that blue-green algae and macrophytes are problematic in the Delta. The relationship between nutrient concentrations or loads and their growth needs further investigation.
- Water hyacinth and other plants have been problematic in some Delta waterways. The relationships between nutrients in water and sediment and the growth of these plants needs futher investigation.
- Microcystis (a toxic algae) blooms have been reported and are of concern for contact recreation, toxicity to aquatic invertebrates and fish and may become a potential drinking water concern if concentrations continue to increase (Lehman et al., 2003, 2005, 2008). Blue green algae grow better in warm water (>20^0c), long residence time and elevated ammonia levels. Consistent with this blue green algal blooms are most common in the fall in the San Joaquin River channel during times of high Old and Middle River reverse flow. Current research using isotopic analysis suggest that ammonia from sewage treatment plants may be an important nitrogen source.

Sources, pathways, loadings, and processes: what sources and processes are most important to understand and quantify?

- Nutrients enter the Delta through direct discharge from wastewater treatment plants, from agricultural runoff and tailwater discharge, urban runoff, and directly through wet and dry atmospheric deposition. A SPARROW (Spatially Referenced Regression on Watershed Attributes) model of nitrogen and phosphorus movement throughout California is currently being developed by the U.S. Geological Survey (Saleh and Domagalski, 2012) that will provide an overall assessment of nitrogen and phosphorus inputs from specific sources. The model (which is based on information collected through 2002) shows that significant sources of nitrogen from the Sacramento River watershed are wastewater treatment plants (31%), farm fertilizer and livestock production (50%), urban land (3%), atmospheric deposition (10%), and forested land (6%). In contrast, virtually all of the nitrogen in the Sacramento River above Lake Shasta is sourced from either forests or atmospheric deposition. Phosphorus sources from the Central Valley are a mix from agricultural land and background geology or soils. Wastewater inputs are locally important.
- Sacramento River discharge is the largest source of nitrogen and phosphorus into Suisun Bay on an annual basis. Seasonally, other sources are important (Senn et al., 2013). Agricultural sources are primarily within the Central Valley and dominate the load below Redding to Freeport. Sacramento Regional Wastewater Treatment Plant effluent adds to the load just below Freeport. The new permit on ammonia discharges for the Sacramento Regional Wastewater Treatment plant will result in a decreases in both ammonia and total dissolved nitrogen. A

plot of the major sources of nitrogen to Suisun Bay along the entire reach of the Sacramento River is shown in **Figure 1**.

- Jassby and Cloern (2000) showed that tributaries to the Delta are the primary sources of organic carbon; primary production within the Delta is secondary, and wastewater discharge is tertiary.
- Nutrient cycling in the delta has not been researched.

Forecasting water quality under different management scenarios: How do ambient water quality conditions respond to different management scenarios? What contaminant loads can the Delta assimilate without impairment of beneficial uses? What is the likelihood that the Delta will be water quality-impaired in the future?

- These questions require (1) the development and use of analytical modeling tools and (2) the development of information to understand the relationship between ambient levels of nutrients and the attainment of beneficial uses. The Drinking Water Policy work group initiated this effort and developed information and tools to begin to answer the first question. More work is needed to develop the appropriate tools and complete the analysis. The development of nutrient water quality objectives for the Delta is required to address the second two questions.

Effectiveness tracking: Are water quality conditions improving as a result of management actions such that beneficial uses will be met?

- Recent management actions have included advanced treatment at several wastewater treatment facilities. Water quality improvements have not yet been evaluated
- Overall, not enough data exists to definitively answer these management questions.

Are loadings changing as a result of management actions?

- Loadings from wastewater treatment facilities adding nutrient removal have measurably reduced their nutrient loads.

Knowledge Gaps

- A fundamental knowledge gap with respect to nutrients and organic carbon is how concentrations, loads, and ecosystem response would change with changing land-use (such as wetland restoration, changes in agriculture, etc.) patterns, and changes in climate, and how this might affect primary productivity and vascular plant growth in various Delta sub-regions. The effect of water resources and residence time from water diversions and the response in primary productivity needs investigation. There is also a gap regarding within Delta processes that contribute nutrients to Delta waterways.

Evaluation by Decision Criteria

How would monitoring this constituent provide a mutual benefit to RMP participants? How would monitoring this constituent attract new stakeholders to participate in funding and/or implementation?

- Nutrients fuel ecosystem processes in the Delta. Knowledge of their temporal and spatial concentrations will be necessary in order to understand food webs and the distribution and abundance of all aquatic species.
- CV-SALTS (http://cvsalinity.org) is a collaborative stakeholder driven and managed program to develop sustainable salinity and nitrate management planning for the Central Valley.
- Data on nutrient concentrations, sources, and ecological condition is needed for the development of nutrient water quality objectives in the Delta. Multiple stakeholders have a vested interest in the collection of this data to support this process. The San Francisco Regional Water Quality Control Board has initiated an nutrient numerical endpoint evaluation and has concluded that the Delta is the major source of nutrients to San Pablo and Suisun Bay. The Central Valley Regional water Quality Control Board has written a nutrient strategy document but is waiting for guidance from State Board on how to proceed with nutrient research.

How could this constituent be monitored with the pool of available financial and in-kind resources? Is special funding available? What opportunities are there for cost-sharing or leveraging?

- Funds from the SWAMP program, wastewater dischargers, and the State and Federal Water Contractors are supporting efforts for the San Francisco Bay nutrient management strategy. The USFWS has supported monitoring for nutrients on a transect through Suisun Bay to the South Bay. The Department of Water Resources has been monitoring nutrients at between 15 to 20 stations in Suisun Bay and the Delta since about 1975. The Interagency Ecological Program, and any program related to wetland restoration in the Delta are potential sources of funding.
- Individual nutrient analyses are relatively inexpensive but can become substantial if all forms are monitored.
- The Regional Board special study may provide some cost-sharing.

- Some continuous sensors for ionic forms of N and P have been installed at existing Delta monitoring stations. See Additional Input below.

How would monitoring this constituent help to address a significant water quality question?

- Nutrients and organic carbon are linked to both ecosystem processes and drinking water suitability. Recent studies have hypothesized that excessive nutrients have contributed to the Pelagic Organism Decline, which has limited water exports. Analysis of this monitoring data could help determine if nutrients actually contribute to beneficial use impairment of the Delta.
- Monitoring of nutrients is consistent with recommendations from the Drinking Water Policy adopted by the Central Valley Board.

How would monitoring data provide key input to an important modeling tool?

- Nutrients data can be used in ecosystem modeling, models of contaminants in drinking water, and biogeochemical models of contaminant transport. These models are needed to simulate potential impacts of different nutrient management strategies, thereby contributing to making decisions regarding nutrient management that benefit the ecosystem.
- Data would provide key input to understand how nutrients can be managed and how various management scenarios would benefit the ecosystem and water supply.

How would monitoring this constituent support existing and/or future policy/regulatory programs?

- Monitoring nitrates could support the new Drinking Water Policy.
- The San Francisco Bay NNE effort could be supported with more monitoring data for Delta outflows.
- Monitoring nitrate in the Delta could support CV-SALTS nitrate management planning for the Central Valley.
- The Delta Plan recommends that nutrient objectives, either narrative or numeric, be developed for the Delta by 2018. Data is needed to support the development of these objectives.

What are the technical challenges to monitoring this constituent?

- Monitoring of nutrients and organic carbon by standard wet chemical techniques is easy and many laboratories have the capability. Although certain forms of N or P have been monitored exclusively because of regulatory needs, it is recommended that the forms of nitrogen and phosphorus mentioned previously be monitored. This includes both dissolved and particulate forms. This is especially necessary for modeling purposes.
- Newer technology has provided the capability for better temporal resolution, at least for some specific nutrients. Optical sensors for nitrate, and fluorescent dissolved organic carbon have proven capability and concentrations correlate very well with laboratory measurements.
- A phosphate sensor has been developed, but needs more testing.
- Recent studies have demonstrated that the knowledge of how nutrients are transported and processed in the environment is greatly increased by the temporal resolution of data gained by continuous sensors.

Why is it timely to address this constituent?

- Delta nutrient water quality objectives need to be developed over the next 5 years.

- Indications of a potential eutrophication in portions of the Delta will require a thorough understanding of nutrient sources and fate in the Delta.

Additional Input

Current Gauging Station Locations with Various Sensors

Most stations have continuous nitrate, dissolved organic carbon, chlorophyll-*a* and phytocyanin. The Cache slough site has the same plus phosphorus.

Sacramento River at Walnut Grove above Georgiana Slough
Cache Slough at Ryer Island
Sacramento River at Decker Island Near Rio Vista
Sacramento River at Freeport
Liberty Island at Hastings Tract Near Rio Vista

Readiness to Proceed

Monitoring of nutrients could be implemented quickly, and there are partnerships that could be developed for sample collection and data sharing.

Ancillary Conditions

Ancillary measurements would include temperature, pH, dissolved oxygen, specific conductance, and chlorophyll-*a*.

Environmental Justice Considerations
[EJ defined at http://www.epa.gov/compliance/environmentaljustice/index.html]

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Contributors

- Stephen McCord (McCord Environmental)
- Drinking Water Policy Workgroup Synthesis (
- SF Bay NNE Ammonia Conceptual Model, David Senn
- Nutrients Data gaps analysis, Lester McKee
- Brian Bergamaschii, U.S. Geological Survey

Figures

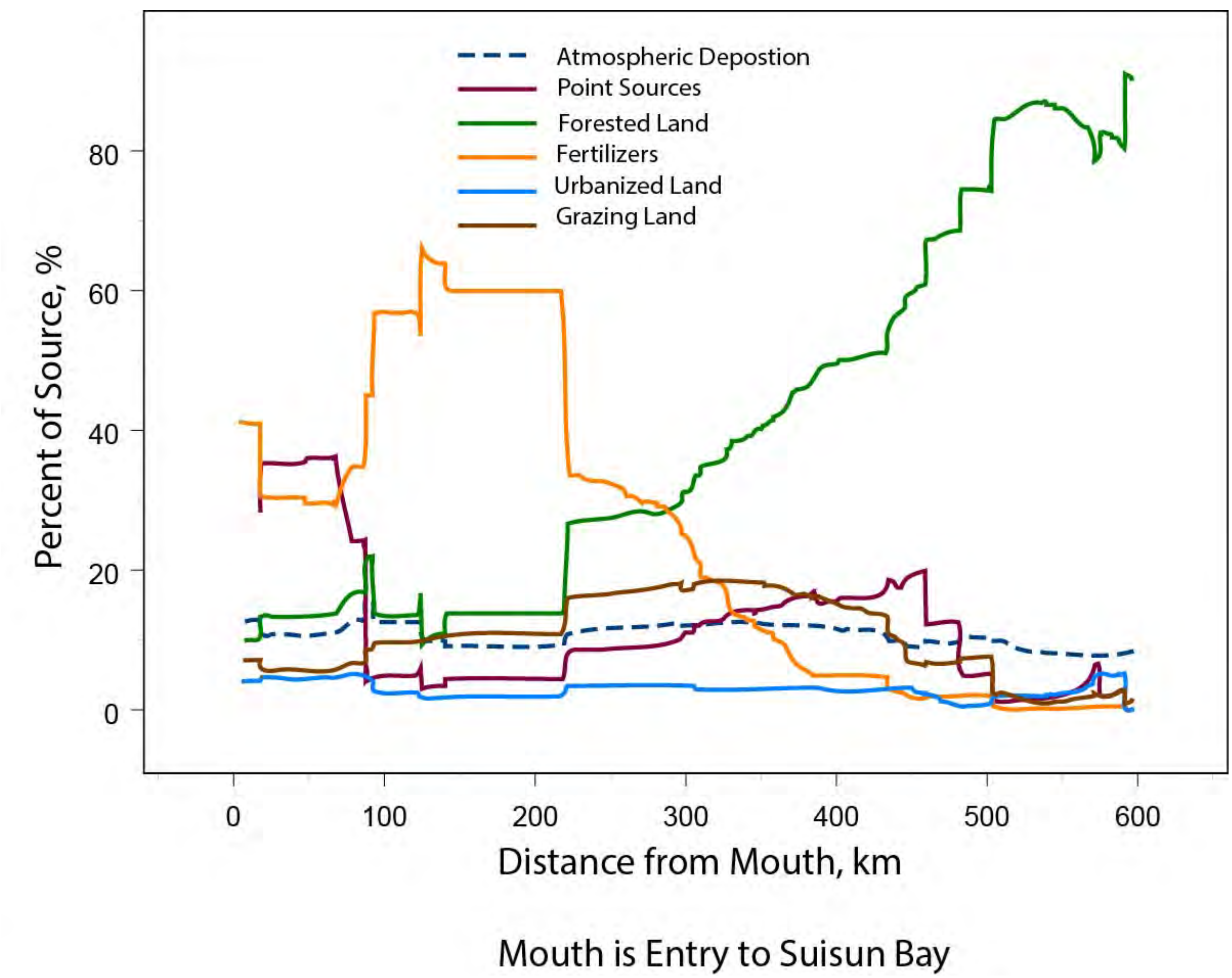


Figure 1. Source shares (percent of load) of total nitrogen from headwaters to mouth. Mouth is defined as entry to Suisun Bay. This plot was produced using the USGS SPARROW (Spatially Referenced Regressions on Watershed Attributes) model. Source data is referenced to 2002.

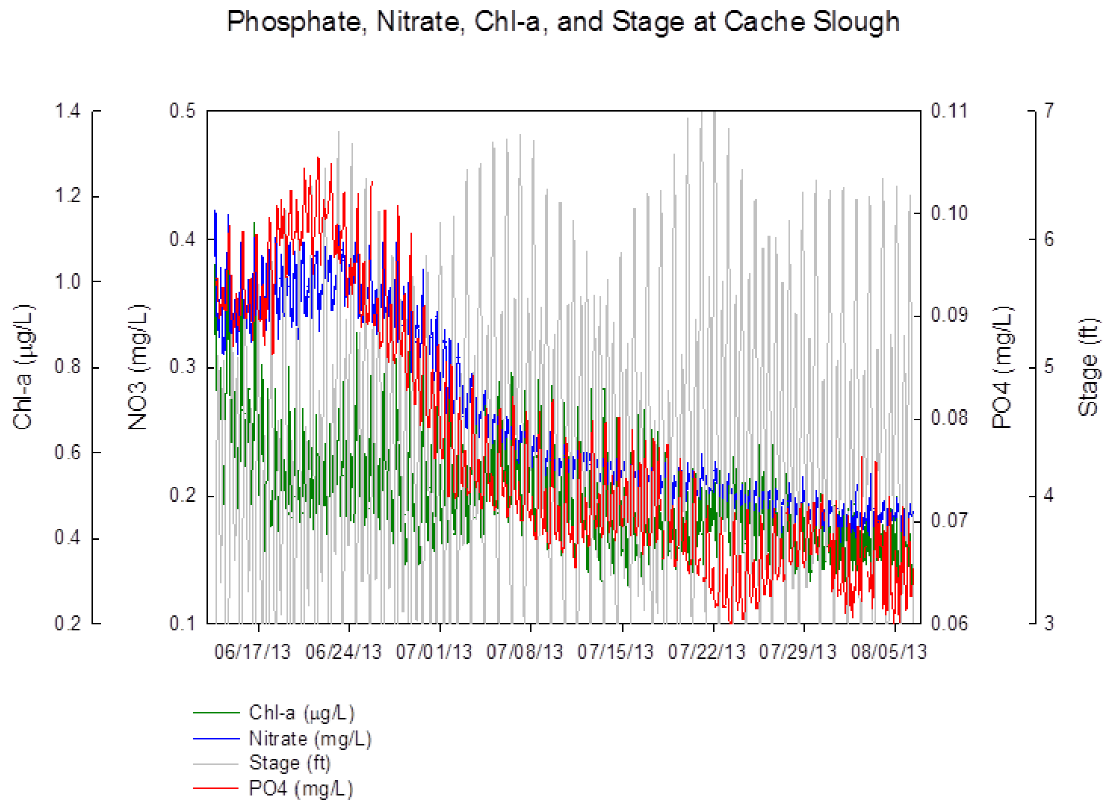


Figure 2. Variation in chlorophyll-*a*, nitrate, river stage, and phosphate at Cache Slough during a two month summer period in 2013.

RMP Constituent Prioritization Fact Sheet
~ Pesticides~

Lead: Joe Domagalski (USGS)

This fact sheet is intended to inform decisions by the Delta RMP Steering Committee (SC) about initial assessment targets. Five fact sheets are being produced, one for each potential initial assessment target: methylmercury, nutrients, pathogens, pesticides, and toxicity. Each fact sheet summarizes existing knowledge (and gaps) based on a consistent outline and guidance. Draft and final results will be presented to the SC to support its decision-making process. Secondary purposes include working with stakeholders to compile and assess relevant information, identifying potential TAC members, and developing knowledge for subsequent monitoring program design.

General Description of Constituent

Pesticides have many uses in California for agriculture, urban and residential areas, and roadways. The types of pesticides used in California changes because of technology, cropping patterns, regulatory action, industry innovation, and needs of growers Pesticides are chemicals used to control pests so all pesticides inherently have some risk. While the U.S. Environmental Protection Agency (U.S. EPA) and the Department of Pesticide Regulation (DPR) regulate pesticides and assess risk, it is important to continuously evaluate pesticides. Both U.S. EPA and DPR have formal processes to deal with pesticide use concerns. For example, DPR is currently reevaluating the use of a class of chemicals known as pyrethroids. The reevaluation is based on monitoring surveys and toxicity studies revealing the widespread presence of pyrethroid residues in the sediment of both agricultural and urban dominated California waterways at levels toxic to *Hyalella azteca*]. Pyrethroid insecticides have also been found in water and probably contributes to toxicity.

It is necessary to consider pesticides of current use and what impacts, if any, they have on the aquatic system. Some pesticides are used with a degree of regularity. Others are related to climatic conditions. Fungicides, for example, tend to be more highly used in response to rain events to avoid crop loss. A list of current use pesticides currently being analyzed by the U.S. Geological Survey in Delta tributaries, along with some legacy compounds and degradation products is shown in **Table 1**. The pesticides shown in Table 1 are extracted for water. Another method is available for pesticides on sediment. Those analytes are shown in Table 2. Considerations for developing this list of analytes was based on a comprehensive analysis of California Department of Pesticide Regulation records and suitability for analysis using gas or liquid chromatography and mass spectrometry. Compounds of high use, or potential impacts, were prioritized.

Core Monitoring and Special Study Options

There will be pesticide monitoring at the Sacramento River at Freeport and the San Joaquin River at Vernalis for the foreseeable future by the U.S. Geological Survey. The USGS will **only** monitor dissolved pesticides and will **not** complete any storm-water runoff studies. The transport of pyrethroid insecticides by suspended sediment will not be part of the USGS monitoring. The greatest external flux of pesticides to the Delta from both dissolved and sediment-associated particles are likely to occur in response to storm pulses. However, other sources need to be considered, such as field drainage, road drainage, and other sources that may not result in widespread contamination, but could impact Delta waterways locally. Continued re-evaluation of products currently being used and adaptive management with respect to deciding which compounds should be monitored will be required. Special studies of within-Delta sources should also be considered, as there is little information currently available.

Summary Statements

Pesticide use in California continues to change in response to changes in land use, economic factors, regulatory actions, and changes in product availability. A number of compounds have been found to contribute to toxicity to invertebrates, but only rarely to fish toxicity, and only very rarely, if ever, affect drinking water quality. The California Department of Pesticide Regulation reports on much of the pesticide use in California and provide locations of application, as well as dates. Pesticides enter streams from storm water runoff, irrigation runoff, runoff from roads, and urban runoff. Pesticides either stay dissolved in water, attached to sediment particles, or some combination which affects their ultimate fate during transport to the Delta as well as their effects.

Available Information and Knowledge Gaps

Brief synopsis of readily available information

Status & trends: is there a problem or are there signs of a problem? Is water quality currently, or trending towards adversely affecting beneficial uses of the Delta?

- The California Department of Pesticide Regulation maintains a reporting database of most pesticides applied in California by licensed applicators. California law requires all agricultural pesticides to be reported monthly to the county agricultural commissioners. Agricultural use in California includes parks, golf courses, cemeteries, rangeland, pastures, and along roadside and railroad rights-of-way so the information covers quite a broad range of sites. This information is invaluable in designing effective monitoring studies since the date and location of active ingredient applied, amongst many other things, are available.

- Pesticide manufacturers also have extensive information on the environmental fate of specific products. That data can also be used to help decide which compounds should be monitored based on chemical properties. However, much of that data are proprietary.
- Two locations with current and past monitoring relevant to the Delta are the Sacramento River at Freeport and the San Joaquin River at Vernalis. Much of the data collected at those sites are from the National Water Quality Assessment (NAWQA) Program and the National Stream Accounting Network (NASQAN) Program of the U.S. Geological Survey. Data from these programs are availble Orlando (2013). Other analyses of these data show that agricultural use of pesticides results in distinct pulses for specific compounds (Johnson et al., 2011) (**Figure 1**), which can be modeled to estimate daily concentrations at anytime of the year.
- A recent one-year study (2012, 2013, James Orlando, USGS, written communication) of pesticides entering the Delta from the Sacramento and San Joaquin Rivers showed that herbicides were the most frequently detected compounds. The most frequently detected compounds were the herbicides diuron (75%), hexazinone (100%), metolachlor (63%), and simazine (64%), the fungicides, azoxystrobin (82%) and boscalid (50%), and the herbicide degradates 3,4-DCA (95%) and DCPMU (43%). These results are based on a single year and cannot be used to extrapolate conditions that may occur in the future. In addition, that study only analyzed pesticides dissolved in water and did not address pesticides in suspended sediment.
- A number of studies have been completed by Donald Weston and collaborators linking pyrethroid concentrations in both sediment and water to toxicity. (for example, Weston et al., 2010, 2012, 2013, and numerous others.
- Because of the changing nature of pesticide use, it is difficult to place a metric on pesticide concentration trends relative to beneficial uses. In some cases, where TMDL actions have been in place, concentrations have shown a decreasing trend. New pesticides used as replacements, undergo a rigorous registration process. However, not all environmental impacts can be predicted.
- The California Department of Pesticide Regulation has conducted a number of relevant studies on surface water. (http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps.htm?filter=surfwater)

Is the issue/contaminant impairing beneficial uses in subregions of the Delta?

- Although pesticide inputs to the Delta are known for some rivers, such as the Sa cramento and San Joaquin, less is known about within Delta sources because of more limited monitoring. In addition, there are still outstanding questions about the toxicity of these pesticides to Delta aquatic species, and how that toxicity is expressed across specific regions. There are a number of studies linking pesticide concentrations in stormwater runoff to toxicity (for example, Weston, and Lydy, 2010).
- The concern for pesticides in surface waters in California is mostly because of aquatic toxicity, especially to invertebrates, including water column and benthic species. Drinking water sources has been impacted by pesticides in the past, but currently it is likely that pesticides are not contributing to that type of impairment in the Delta or its tributaries. There are very few cases of direct acute (ie., mortality) toxic effects on fish. There is also interest in sub-lethal toxicity. For example, (Laetz et al., 2009, 2013, examined olfactory responses to salmon and noted a possibility of sub-lethal impacts at environmentally realistic concentrations of pesticide mixtures. Weston and Lydy, (2010) found toxicity to a benthic invertebrate from agricultural and urban sources of pyrethroid insecticides
- In Region 9, organophosphate and pyrethroid pesticides have been identified as causes of water quality impairment under Section 303(d) of the Clean Water Act (SWRCB 2010).

Are trends similar or different across different subregions of the Delta?

- There is insufficient data available to answer this question.

Sources, pathways, loadings, and processes: what sources and processes are most important to understand and quantify?

- The most important sources of pesticide inputs to the Delta are from runoff driven by rain events or irrigation, from multiple agricultural and urban sources. There are pesticides in groundwater, which probably contribute to Delta surface water loads from groundwater discharge, but those are likely to be minor. Although studies are more limited, pesticides in rain have been measured and found to contribute to stream loads (Zamora et al., 2013).
- Pesticides are transported either in the dissolved form, or attached to particles, or in some combination depending on suspended sediment concentrations. Potential effects from specific compounds are dependent on how the transport occurs and where the pesticides are ultimately deposited.

What are the relative contributions of internal sources and sinks to the Delta contaminant budgets?

- There is less knowledge about within Delta contributions of pesticides and how those pesticides are transported to other reaches of the Delta. There is also likely some input of pesticides from wastewater facilities, but those concentrations and loads are also poorly characterized.

Forecasting water quality under different management scenarios: How do ambient water quality conditions respond to different management scenarios?

- Management actions, such as TMDLs can effectively reduce concentrations to attain water quality goals. A number of options are available including strategies to minimize runoff by use of buffer strips, alternative spray equipment, and other techniques have been effective. Product substitution is also an option.
- Concentration or loading pulses of pesticides occur throughout the year with overlaps that result in mixtures of pesticides. Rivers that are tributaries to the Delta will also have seasonal pulses of herbicides and insecticides in the winter months as a result of stormwater runoff, which eventually discharge to the Delta. Agricultural patterns and pesticide use continually changes in California as a result of economic factors and regulatory factors affecting the use of certain compounds. TMDL programs have been effective at bringing concentrations down where applied. One example is the agricultural TMDL for diazinon. Concentrations have been shown to be lower and below targets following implementation of the TMDL (Figure 2).

What contaminant loads can the Delta assimilate without impairment of beneficial uses?

- There is insufficient information on how to answer this question. Loads of pesticides are less relevant to this question as are concentrations, since lethal or sub-lethal effects are only sensitive to concentrations.
- Pesticides tend to be transient in the environment because of degradation. Seasonal pulses may affect portions of a food web, which could then affect other organisms not directly affected by toxicity because of a lack of food. Those seasonal pulses may result in elevated concentrations for brief periods of time with potential effects on aquatic food webs.

What is the likelihood that the Delta will be water quality-impaired in the future?

- There is insufficient data available to answer this question.

Effectiveness tracking: Are water quality conditions improving as a result of management actions such that beneficial uses will be met?

- Johnson and Domagalski, 2011, used a statistically based trends model to show how diazinon concentrations decreased to acceptable levels because of a TMDL action. Loadings can constantly change as new pesticides are introduced, and as new management options are implemented. Continued monitoring of pesticide concentrations are necessary to demonstrate the effectiveness of these management options as well as to determine any impairments for other pesticides especially due to changes in use or newly registered compounds

Are loadings changing as a result of management actions?

- It is known that loadings of some pesticides, such as organophosphate insecticides have decreased in the tributary waters of the Delta (Sacramento and San Joaquin Rivers). Although it can be assumed that loadings in the Delta have also decreased there is insufficient monitoring of Delta waterways to answer this definitively.

Knowledge Gaps

- Seasonal monitoring of Delta waterways for pesticides being used in Delta agriculture is not adequate for the understanding of within Delta sources.
- A complete understanding of the relative amounts of pesticides transported in the dissolved phase, the amount transported with suspended sediment, and the amounts transported as some combination is necessary for both the tributary streams to the Delta and Delta waterways. There is sufficient information on pesticide properties from a variety of sources to design monitoring programs for both water and sediment transported pesticides.
- The transport of current use pesticides in storm water runoff is not being effectively tracked. Short-term pulses in toxicity may occur during these events. The effects of complex mixtures of pesticides, including current use pesticides, on aquatic organisms is not known. Sub-lethal effects from individual compounds or mixtures is not completely understood.
- Degradation products of pesticides are not always monitored. Analytical methods exist for degradation products, but many are not being monitored.
- The question on contaminant loads that the Delta can assimilate without impairing beneficial uses is a critical information gap.
- Neither NAWQA nor NASQAN consider storm water runoff so that is one gap in the information.

Evaluation by Decision Criteria

How would monitoring this constituent provide a mutual benefit to RMP participants? How would monitoring this constituent attract new stakeholders to participate in funding and/or implementation?

- Pesticide monitoring will be provide a mutual benefit to RMP participants. See below.
- Pesticide concentrations can be used in other studies, such as the identification of toxicants in water and sediment.
- Continued monitoring is necessary for some agencies, such as California Department of Pesticide Regulation, to decide whether further investigations or regulations are necessary. Monitoring of pesticide concentrations relative to benchmarks, such as toxicity, are necessary.
- Pesticide occurrences and concentrations are important parameters that can be used by various agencies in 1. defining water quality in the delta; 2. evaluating risks of exposures in the aquatic system; 3. making regulatory decisions to mitigate the potential impacts.

How could this constituent be monitored with the pool of available financial and in-kind resources? Is special funding available? What opportunities are there for cost-sharing or leveraging?

- The U.S. Geological Survey will continue to monitor the Sacramento River at Freeport and San Joaquin River at Vernalis sites for a portion of the pesticides of interest. Sampling will not include storm water runoff.
- Funds may be available from the State Water Board and/or the State and Federal Contractors Water Agency

How would monitoring this constituent help to address a significant water quality question?

- Monitoring pesticides would help to address significant water quality questions. This is particularly true for understanding toxicity and sub-lethal effects.

How would monitoring data provide key input to an important modeling tool?

- Monitoring data would provide the basis for trend analysis and predictions of daily concentrations, which could be related to toxicological data.
- The modeling of pesticides, based on currently available data, can be used to guide future monitoring studies, and to place the monitoring data in the context of risk assessment. Statistically based models Risk assessment, based on statistically based models, will allow for an analysis of how frequently sensitive organisms are exposed to concentrations above a toxicity threshold.

How would monitoring this constituent support existing and/or future policy/regulatory programs?

- Monitoring pesticides would support regulatory programs designed for the protection of aquatic species, for reduction of toxicity in ambient waters, and provide a basis for management of specific compounds

What are the technical challenges to monitoring this constituent?

- Technical challenges are developing methodology for the analysis of new compounds, which have not previously been analyzed. The laboratory methods require suitable detection limits relative to potential toxicity, and acceptable levels of recovery. For example, some pyrethroid insecticides have toxicity at concentrations that were too low to measure by earlier methods, and even the current methods are just barely able to measure toxicity relevant concentrations for pyrethroids in water. Suitable methods for new pesticides may have to be developed. New pesticides introduced to the market need laboratory prove-out for suitable quality control. An example of a currently available analytical scan for pesticides is shown in Table 1.
- Degradation products of pesticides, which may still by toxic, pose challenges for analytical method development.

Why is it timely to address this constituent?

- Aquatic toxicity caused by pesticides is well documented in California. The Sacramento and San Joaquin Rivers, in particular, are sources of pesticides to the Delta. Agricultural and other pesticide users within the Delta may also contribute to load in Delta waterways. A number of agricultural and urban streams in both the Sacramento and San Joaquin Valleys are being considered for TMDL actions for pyrethroid insecticides.

Additional Input

Readiness to Proceed

Analytical methodology exists for current use pesticides and pesticides which are known to contribute to aquatic toxicity, such as pyrethroids, organophosphate insecticides, and some herbicides. There are no real roadblocks to implementing a monitoring or special studies program.

Ancillary Conditions

Ancillary measurements should include temperature, pH, dissolved oxygen, nutrient concentrations. When possible, measurements should be taken at locations where streamflow is measured.

Environmental justice considerations

[EJ defined at http://www.epa.gov/compliance/environmentaljustice/index.html]

- Members of disadvantaged communities in the Delta region catch and consume Delta fish in disproportionately high numbers (Shilling et al., 2010). If pesticides in the Delta are reducing fishing opportunities, then disadvantaged communities may be disproportionately affected.

Tables and Figures

Table 1. List of Current Use Pesticides Monitored by U.S. Geological Survey in Water. [1.]

Compound	NWIS Parameter Code	Method detection limit (ng/L)	Analytical Method
Acetamiprid	68302	3.6	LC/MS/MS
Alachlor	65064	1.7	GC/MS
Allethrin	66586	6.0	GC/MS
Atrazine	65065	2.3	GC/MS
Azoxystrobin	66589	3.1	GC/MS
Bifenthrin	65067	4.7	GC/MS
Boscalid	67550	2.8	GC/MS
Butylate	65068	1.8	GC/MS
Carbaryl	65069	6.5	GC/MS
Carbofuran	65070	3.1	GC/MS
Chlorothalonil	65071	4.1	GC/MS
Chlorpyrifos	65072	2.1	GC/MS
Clomazone	67562	2.5	GC/MS
Clothianidin	68221	6.2	LC/MS/MS
Cycloate	65073	1.1	GC/MS
Cyfluthrin	65074	5.2	GC/MS
Cyhalothrin	68354	4.5	GC/MS
Cypermethrin	65075	5.6	GC/MS
Cyproconazole	66593	4.7	GC/MS

Cyprodinil	67574	7.4	GC/MS
DCPA	65076	2.0	GC/MS
p,p'-DDD	65094	4.1	GC/MS
p,p'-DDE	65095	3.6	GC/MS
p,p'-DDT	65096	4.0	GC/MS
Deltamethrin	65077	3.5	GC/MS
Desulfinylfipronil	66607	1.6	GC/MS
Diazinon	65078	0.9	GC/MS
3,4-Dichloroaniline (3,4-DCA)	66584	5.2	LC/MS/MS
3,5-Dichloroaniline (3,5-DCA)	67536	7.6	GC/MS
3,4-Dichlorophenylurea (DCPU)	68226	4.3	LC/MS/MS
Difenoconazole	67582	10.5	GC/MS
(E)-Dimethomorph	67587	6.0	GC/MS
Dinotefuran	68379	5.5	LC/MS/MS
Diuron	66598	3.2	LC/MS/MS
EPTC	65080	1.5	GC/MS
Esfenvalerate	65081	3.9	GC/MS
Ethalfluralin	65082	3.0	GC/MS
Etofenprox	67604	2.2	GC/MS
Famoxadone	67609	2.5	GC/MS
Fenarimol	67613	6.5	GC/MS
Fenbuconazole	67618	5.2	GC/MS
Fenhexamide	67622	7.6	GC/MS
Fenpropathrin	65083	4.1	GC/MS
Fipronil	66604	2.9	GC/MS
Fipronil sulfide	66610	1.8	GC/MS
Fipronil sulfone	66613	3.5	GC/MS
Fluazinam	67636	4.4	GC/MS
Fludioxinil	67640	7.3	GC/MS
Fluoxastrobin	67645	4.2	GC/MS
Flusilazole	67649	4.5	GC/MS
Flutriafol	67653	4.2	GC/MS
τ-Fluvalinate	65106	5.3	GC/MS
Hexazinone	65085	8.4	GC/MS
Imazalil	67662	10.5	GC/MS
Imidacloprid	68426	4.9	LC/MS/MS
Iprodione	66617	4.4	GC/MS
Kresoxim-methyl	67670	4.0	GC/MS
Malathion	65087	3.7	GC/MS
Metconazole	66620	5.2	GC/MS
Methidathion	65088	7.2	GC/MS
Methoprene	66623	6.4	GC/MS
Methylparathion	65089	3.4	GC/MS

Metolachlor	65090	1.5	GC/MS
Molinate	65091	3.2	GC/MS
Myclobutanil	66632	6.0	GC/MS
N-(3,4-Dichlorophenyl)-N'-methylurea (DCPMU)	68231	3.0	LC/MS/MS
Napropamide	65092	8.2	GC/MS
Oxyfluorfen	65093	3.1	GC/MS
Pebulate	65097	2.3	GC/MS
Pendimethalin	65098	2.3	GC/MS
Pentachloroanisole (PCA)	66637	4.7	GC/MS
Pentachloronitrobenzene (PCNB)	66639	3.1	GC/MS
Permethrin	65099	3.4	GC/MS
Phenothrin	65100	5.1	GC/MS
Phosmet	65101	4.4	GC/MS
Piperonyl butoxide	65102	2.3	GC/MS
Prometon	67702	1.8	GC/MS
Prometryn	65103	2.5	GC/MS
Propanil	66641	10.1	GC/MS
Propiconazole	66643	5.0	GC/MS
Propyzamide	67706	5.0	GC/MS
Pyraclostrobin	66646	2.9	GC/MS
Pyrimethanil	67717	4.1	GC/MS
Resmethrin	65104	5.7	GC/MS
Simazine	65105	5.0	GC/MS
Tebuconazole	66649	3.7	GC/MS
Tefluthrin	67731	4.2	GC/MS
Tetraconazole	66654	5.6	GC/MS
Tetramethrin	66657	2.9	GC/MS
Thiacloprid	68485	3.8	LC/MS/MS
Thiamethoxam	68245	3.9	LC/MS/MS
Thiobencarb	65107	1.9	GC/MS
Triadimefon	67741	8.9	GC/MS
Triadimenol	67746	8.0	GC/MS
Trifloxystrobin	66660	4.7	GC/MS
Triflumizole	67753	6.1	GC/MS
Trifluralin	65108	2.1	GC/MS
Triticonazole	67758	6.9	GC/MS
Zoxamide	67768	3.5	GC/MS

[1.)] LC/MS/MS – Liquid chromatography, mass spectrometry, mass spectrometry; GC/MS – gas chromatography, mass spectrometry]

Table 2. Pesticides Analyzed in Sediment, U.S. Geological Survey Laboratory, Sacramento, CA

Compound	**Sediment MDL (ug/kg)**
3,4-DCA	1.3
3,5-DCA	1.5
Alachlor	0.6
Allethrin	1.7
Atrazine	1.5
Azinphos methyl	1.7
Azoxystrobin	0.9
Benefin	1.7
Bifenthrin	0.6
Boscalid	1.2
Butralin	1.6
Butylate	1.3
Captan	3.1
Carbaryl	1.2
Carbofuran	1.2
CDEPA	1.3
Chlorothalonil	1.1
Chlorpyrifos	0.9
Clomazone	2.0
Coumaphos	1.2
Cyahlofop-butyl	0.8
Cycloate	0.8
Cyfluthrin	1.3
Cyhalothrin	0.7
Cypermethrin	1.2
Cyproconazole	1.0
Cyprodinil	1.7
DCPA	1.7
Deltamethrin	1.3
Diazinon	1.6
Difenoconazole	1.0
Dimethomorph	1.5
Dithiopyr	1.3
EPTC	0.8
Esfenvalerate	1.0
Ethalfluralin	1.2

Etofenprox	1.0
Famoxadone	1.7
Fenarimol	1.4
Fenbuconazole	1.8
Fenhexamide	2.5
Fenpropathrin	1.0
Fenpyroximate	1.9
Fenthion	2.0
Fipronil	1.6
Fipronil desulfinyl	1.8
Fipronil desulfinyl amide	2.0
Fipronil sulfide	1.5
Fipronil sulfone	1.0
Fluazinam	2.1
Fludioxinil	2.5
Flufenacet	1.0
Flumetralin	1.2
Fluoxastrobin	1.2
Flusilazole	2.2
Flutolanil	2.1
Flutriafol	1.1
Hexazinone	0.9
Imazalil	1.8
Indoxacarb	2.4
Iprodione	0.9
Kresoxim-methyl	0.5
Malathion	1.0
Metalaxyl	1.9
Metconazole	1.2
Methidathion	1.8
Methoprene	1.6
Methyl parathion	1.1
Metolachlor	0.7
Molinate	1.0
Myclobutanil	1.7
Napropamide	0.9
Novaluron	1.1
Oxydiazon	1.4
Oxyfluorfen	1.9
p,p'-DDD	1.0
p,p'-DDE	1.0

p,p'-DDT	0.8
PCA	1.1
PCNB	1.1
Pebulate	0.9
Pendimethalin	0.8
Permethrin	0.9
Phenothrin	0.9
Phosmet	0.9
Piperonyl butoxide	1.2
Prodiamine	1.4
Prometon	2.7
Prometryn	1.3
Propanil	2.2
Propargite	2.2
Propiconazole	1.1
Propyzamide	1.5
Pyraclostrobin	1.1
Pyridaben	1.2
Pyrimethanil	1.1
Resmethrin	1.3
Simazine	1.3
tau-fluvalinate	1.2
Tebuconazole	1.2
Tebupirfimfos OA	2.0
Tebupirimfos	1.5
Tefluthrin	0.7
Tetraconazole	1.1
Tetradifon	2.0
Tetramethrin	0.9
Thiazopyr	1.9
Thiobencarb	0.6
Triadimefon	1.5
Triadimenol	1.5
Triallate	1.4
Tribufos	2.2
Trifloxystrobin	1.0
Triflumizole	1.1
Trifluralin	0.9
Triticonazole	1.8
Vinclozolin	1.2
Zoxamide	1.1

Figure 1. Wave models for the Sacramento and San Joaquin Rivers showing seasonal pulses of pesticides from historical monitoring data, (1993-2005). These models are built from monitoring data and are used to calibrate relationships between concentration and river discharge and can be used to model daily concentrations. The wave is unitless. Decimal time is based on a year. A decimal time of 0.5, for example, is June 30.

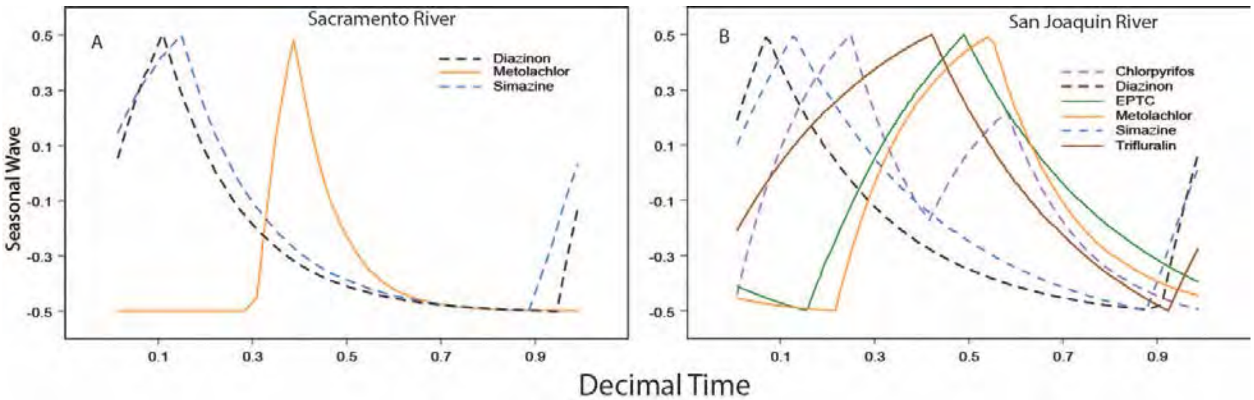
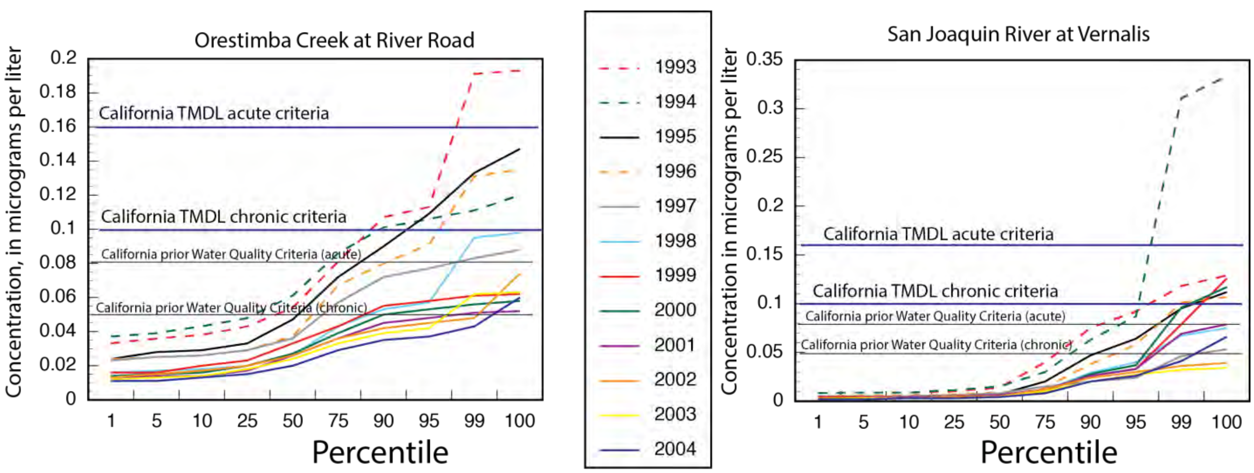


Figure 2. Simulated diazinon concentrations for two locations in the San Joaquin Valley using the wave model. The percentile refers to the portion of the year a particular concentration was below the level corresponding to the y-axis.



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Contributors

- Stephen McCord (McCord Environmental)
- Rachel Kubiak (Western Plant Health)
- Debra Denton, U.S. E.P.A. Region IX
- Xin Deng, Nan Singhasemanon, David Duncan, Department of Pesticide Regulation
- Donald Weston, UC Berkeley

RMP Constituent Prioritization Fact Sheet
~ Ambient Toxicity ~

Lead: Thomas Jabusch (SFEI-ASC)

This fact sheet is intended to inform decisions by the Delta RMP Steering Committee (SC) about initial assessment targets. Six fact sheets are being produced, one for each potential initial assessment target: ambient background characterization, methylmercury, nutrients, pathogens, pesticides, and toxicity. Each fact sheet summarizes existing knowledge (and gaps) based on a consistent outline and guidance. Draft and final results will be presented to the SC to support its decision-making process. Secondary purposes include working with stakeholders to compile and assess relevant information, identifying potential TAC members, and developing knowledge for subsequent monitoring program design.

Overview

General Description

Toxicity in waterways is one of the primary water quality concerns in the Delta: essentially all Delta waterways are currently on the Clean Water Act Section 303(d) list as impaired waterbodies for toxicity. The Delta ecosystem is being described as being in crisis and toxicity impacts have been implicated as one of the possible causes for the decline of native species in the Delta (Aquatic Science Center 2011).

Concerns over the presence of toxic contaminants in Delta waters were a main driver for initiating the RMP, with the purpose to address the information needs for a toxicity response program in the Delta (State Water Board et al. 2008). The RMP could help address toxicity issues in three ways: 1) identifying and eliminating unknown sources of toxicity impairment (the pollutant source for the majority of Delta waterways listed as impaired for toxicity is unknown) so that they can be addressed, 2) evaluating the efficacy of management approaches in reducing toxicity impairments to Delta waterways from known sources, such as agricultural and urban runoff (including storm sewers)(State Water Resources Control Board 2010), and 3) early recognition of potential future toxicity impairments that may go unrecognized.

Ambient toxicity testing can be used as an assessment tool to support these efforts. It indicates the degree to which an ambient water or sediment sample is toxic. Ambient toxicity is evaluated based on an established target (e.g., organism, organ, tissue, cell, or a subcellular component), test method, and endpoint. Acute toxicity tests typically use mortality as the test endpoint, while chronic toxicity tests use sublethal organism responses, such as growth or reproduction. Tables 1 and 2 provide an overview of test organisms and toxicity tests that can be applied to freshwater systems.

Toxicity testing aggregates the effects of chemical stressors (pesticides, heavy metals, chlorinated compounds) with other controlled variables. Therefore it provides a screening tool that can help environmental managers to prioritize efforts. Patterns of toxicity can provide information about levels and trends of pollutant impacts and can provide linkages to, and guide information gathering on, particular land use activities (e.g., pesticide applications) or meteorological events (e.g., stormwater discharge events). In addition, toxicity testing can be allocated over both space and time to assess the efficacy of best management practices. Used in conjunction with targeted chemical analyses and/or follow-up toxicity identification evaluations (TIEs), toxicity testing can help identify the cause(s) of any observed toxicity.

Toxicity testing is a common tool applied to regulatory/compliance assessments in California, and is applied based on the narrative toxicity objective (i.e., no toxicants in toxic amounts); note that the State Water Board is currently considering the application of numeric objectives for point source dischargers. Regulatory programs that require toxicity testing include National Pollutant Discharge Elimination System (NPDES) permits for wastewater treatment plants, municipal stormwater discharge permits, and waste discharge requirements (WDRs) for irrigated lands, among others. Many of these programs also use toxicity identification evaluations (TIEs) coupled with analytical chemistry to identify the cause(s) of the toxicity, which can lead to the development of best management practices to reduce/eliminate the toxicity.

Site-specific considerations will likely be relevant for assessing toxicity in the Delta. EPA's Office of Water (OW) has recently released new guidance on the use of aquatic toxicity benchmarks for deriving site-specific water quality criteria (USEPA 2013). The new guidance is intended to provide a decision process to determine which aquatic toxicity test data are most appropriate for use in deriving aquatic life criteria at a particular site. It applies to situations where nationally recommended aquatic life criteria might be considered under- or overprotective. This is the case if the aquatic community at a given site has different sensitivities than the species included in the national criteria data set. Site-specific criteria can also take into account the possibility that site-specific physical and chemical characteristics may alter the biological availability and/or toxicity of a material.

Core Monitoring and Special Study Options

- Available information suggests that insecticides and herbicides are the cause for most of the toxicity observed in the Delta between 2001 and 2009 (Weston and Lydy 2010, Markewicz et al. 2012). Therefore, toxicity monitoring and studies could be designed specifically to add value to pesticide monitoring and studies (see pesticide factsheet), if these are prioritized.

- Special studies could be employed to evaluate management linkages to patterns of toxicity. For example, special studies could be used to evaluate the cumulative effects of implemented management practices on receiving waters on the regional and/or subregional scale. Or, focused toxicity testing using species with known sensitivities to certain types of pesticides (e.g. *Hyalella* for pyrethroids or *Ceriodaphnia* for diazinon and chlorpyrifos) could be employed to demonstrate toxicity reduction in receiving water systems in response to reduced pesticide loading in tailwater runoff or stormwater systems.

- As a component of the core monitoring program, toxicity testing could help assess regional and subregional conditions. Sampling periods and locations would need to capture the expected spatial and temporal variability of toxicity events, their sources, and their significance.

- An assessment cycle that involves several (maybe alternating) water sampling periods spaced over several years would capture some of the temporal variability of water column toxicity events associated with different pesticide use patterns. Sampling after a winter rain event will characterize stormwater-related toxicity in the water column (Werner et al. 2010, Weston and Lydy 2010). Spring runoff is typically identified as an important monitoring period because spring runoff is likely to carry pesticides applied to agricultural crops in the winter and early spring well as toxic contaminants from urban runoff, and at the same time, spring is also a critical period for several pelagic species. A sampling event during the irrigation season (late summer/early fall) would be positioned to catch toxic effects due to drift or runoff of pesticides and other compounds from irrigated agricultural and urban areas. A fall sampling period could support an assessment of toxicity from sources that do not have a strong seasonal signal, such as wastewater discharges.

- Sediment toxicity is somewhat less variable than water column toxicity and one representative sampling event every three years may suffice to capture temporal trends.

- A full assessment of aquatic toxicity conditions will require 30-40 samples per assessment period to ensure that interpretations will be statistically robust. If a program goal is to complete a full assessment of Delta conditions every five years, then 10 water column samples would be required for each spatial or temporal stratum each year.

- A sampling design that includes both probabilistic (random) and targeted sites would be suited to assess status and trends of toxicity in the Delta. The strength of this approach is that the probabilistic element will support conclusions about conditions across the entire Delta, and about any strata or subpopulations defined through poststratification in the data analysis (e.g. by waterbody type/size, land use, or subregion), while the targeted element will support conclusions about conditions at specific sites or areas of particular concern. Depending on existing questions and pending initial monitoring results, local intensification of the random design may be desired.

- Chemical analyses and toxicity identification evaluations (TIEs) can be employed in combination with toxicity testing to determine causes of water and sediment toxicity.

Summary Statements

- Delta waterways and some waterbodies leading to the Delta are listed as impaired for toxicity but there is no Deltawide overview of toxicity patterns. Employing toxicity testing as a component of the core program will help evaluate the spatial and temporal extent of toxicity and support conclusions about overall conditions and trends in these. Estuarine conditions change rapidly and there is significant annual variability. Most existing monitoring projects are localized short-term studies making it challenging to extrapolate the results to assess long-term regional patterns.

- Toxicity testing is cheaper than analyzing for all potential chemical constituents. Information gained from toxicity testing can help guide decisions about the types of chemical analyses needed, as well as when and where to characterize chemical impacts and stressors.

- TIEs, although expensive relative to the initial toxicity tests, can provide useful information when paired with analytical chemistry to identify the cause(s) of toxicity.

- Toxicity testing provides context for chemical analyses that is helpful for assessing potential water quality impacts, because 1) no other type of analyses can integrate the effects of chemical and physical stressors, specifically addressing additivity, synergism, and antagonistic effects of these stressors, which is key to understanding the complex mixtures found in the environment; 2) there is a dearth of publicly available toxicity information for some of the most highly used pesticides, making it challenging to interpret results of chemical monitoring without toxicity information, and 3) since chemical-analytical method development is not keeping up with the emergence of new chemicals on the market and in the environment, toxicity testing provides an option for screening for potential problems.

- ❖ Test species vary in sensitivities. The advantage of this variability is that different test species can be employed to assess impacts of different types of stressors. The disadvantage is that some traditional species used for detecting effects of well-characterized contaminants are not very sensitive to some new contaminants. The use of biomarkers can be a reasonable and cost-effective alternative to toxicity testing with the most sensitive species.

Available Information and Knowledge Gaps

Brief Synopsis of Readily Available Information

Status & trends: is there a problem or are there signs of a problem?

- Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta?

Yes. Delta waterways are on the Clean Water Act Section 303(d) list as impaired waterbodies for sediment toxicity and unknown aquatic toxicity. The two most comprehensive studies to date relating to toxicity in the Delta conclude that toxic effects on Delta species remain a concern.

- ❖ Johnson et al. (2010) concluded from a review of all available toxicity data collected mostly at the periphery of the Delta that toxicity conditions generally improved from the 1960s, with the least toxicity observed during the last decade (during the Pelagic Organisms Decline or POD). However, they also conclude that water and sediment toxicity to invertebrates is widespread in waterways of the Central, South, and North Delta, including the mainstem rivers.

- ❖ Toxicity data collected by the State Water Board's Surface Water Ambient Monitoring Program (SWAMP) between 2001 and 2009 indicate that the potential for toxic effects on Delta species remains a cause for concern (see **Figures 1** and **2**) (Markewicz et al. 2010).

- Is the issue/contaminant impairing beneficial uses in subregions of the Delta?

The answer is yes, based on what we know. However, data have not been collected systematically to address this management question. Available information allows conclusions about monitored areas and sites but cannot be used to draw inferences about unmonitored areas. Several studies have identified *Hyalella azteca* (a primarily benthic invertebrate) toxicity in urban stream sediments and the water column, however, the fate and transport of the causal toxicants is not understood and toxicity in the downstream waterbodies may be less pronounced. Toxicity monitoring at more Delta sites using a probabilistic design will be necessary to obtain a more complete answer to this question. What the available data has been able to show about certain areas and locations includes:

- Sacramento urbanized area: Sediment toxicity to the invertebrate *H. azteca* in urbanized areas appears to be a statewide issue. It was found to be widespread in suburban creeks of the Sacramento metropolitan area (which was one of the monitored areas) and is linked to the presence of pyrethroid pesticides. Samples collected further downstream in the Sacramento River had much lower concentrations of pyrethroids and lower frequency of toxicity (Weston et al. 2005, Markewicz et al. 2012).

- Cache Slough Complex: A recent study funded by SWAMP and the Interagency Ecological Program (IEP) has observed water toxicity in Cache Slough and creeks draining Vacaville and surrounding areas, using a 96-hour *H. azteca* protocol. The toxicity is linked to the presence of pyrethroid insecticides in urban and agricultural runoff (Aquatic Science Center 2012).

- Stockton area: Markewicz et al. (2012) found low to moderate water toxicity to the cladoceran *Ceriodaphnia dubia* and the alga *Pseudokirchneriella subcapitata* to be widespread in agricultural and urban areas around Stockton. Sediment toxicity to *H. azteca* was less pervasive than water toxicity, but was high in some locations (Markewicz et al. 2012). Pyrethroid-related water toxicity was observed in the San Joaquin River in isolated instances (Weston and Lydy 2010).

- Other sites in the Delta where toxicity has been observed include the Terminous Tract and Potato Slough (moderate toxicity to algae and invertebrates), Marsh Creek (high sediment toxicity), City of Antioch (high sediment toxicity and water toxicity to every test species, including fish), and agricultural drains around Tracy (water toxicity to every test species) (Anderson et al. 2013, Markewicz et al. 2012).

- Coverage of urbanized waterways and other areas within the boundaries of the Delta is incomplete. For example, no information exists for the urban areas of Davis, Woodland, or Dixon (lower Sacramento River watershed) and Manteca, Lathrop, Lodi, and Galt (lower San Joaquin River watershed).

- Are trends over time similar or different across different subregions of the Delta?

The question is difficult to address because the available evidence focuses primarily on a particular watershed or reach at a time, or on a single category of pesticide. Studies in the 1990s have mostly documented the biological effects of organophosphate insecticides, a group of dormant spray pesticides applied in stone-fruit orchards (Kuivila and Foe 1995). Since then, use of the organophosphate-based pesticides diazinon and chlorpyrifos has been reduced in agriculture and eliminated in urban environments and pyrethroid insecticides have taken their place for many uses. As a result, the occurrence of toxicity in urban tributaries in tests using

Ceriodaphnia, *Daphnia magna*, and *Selenastrum* has decreased significantly since the 2005 ban of diazinon and chlorpyrifos for urban uses (Lundberg and Laurenson 2012). Recent studies have documented toxicity to the invertebrate *Hyalella azteca* in urban runoff, agricultural runoff, and wastewater effluent, with nearly all the toxicity believed to be due to pyrethroids (Weston and Lydy 2010). However, studies by Pacific EcoRisk (Clark et al. 2012) and UC Berkeley (Weston et al. 2012) have demonstrated that laboratory populations of *H. azteca* may overestimate toxicity to resident *H. azteca*.

Sources, pathways, loadings, and processes: what sources and processes are most important to understand and quantify?

- Which sources, pathways, loadings, and processes contribute most to impacts? What are the relative contributions of each source?

- ❖ There remains much uncertainty with regards to sources of toxicity. For example, there are a total of 30 303(d) listings for toxicity-impaired waterbodies in the Delta and on its periphery, of which 20 are listings for unknown toxicity and 10 for sediment toxicity. The source of the toxicity is unknown for 15 of the unknown toxicity listings and 5 of the sediment toxicity listings. Agriculture has been identified as the source of toxicity for 8 of these listings (4 unknown toxicity listings and 4 sediment toxicity listings) and urban runoff/storm sewers have been identified as the sources of toxicity for 2 listings (1 unknown toxicity and 1 sediment toxicity listing)(State Water Resources Control Board 2010).

- ❖ TIEs have identified pyrethroids as the major chemical class of concern in urban runoff and mixtures of organophosphates and pyrethroids as the major chemical classes of concern in agricultural runoff (Weston and Lydy 2010).

- ❖ The impact of tributary sources to the downstream Delta, and the persistence of pyrethroids and other sources of toxicity to this area (e.g., fate and transport) are not well understood. Urban runoff sources of toxicity are most prominent during periods of wet weather (Weston and Lydy 2010).

- What are the relative contributions of internal sources and sinks to the Delta contaminant budgets?

- ❖ There is insufficient information to support an answer. Toxicity monitoring at more Delta sites will be necessary to obtain an accurate picture of the effects of within-Delta inputs on the Delta ecosystem (Markewicz et al. 2012).

Forecasting water quality under different management scenarios

- How do ambient water quality conditions respond to different management scenarios?

- ❖ There is insufficient information to support an answer. Appropriate toxicity testing methods such as biomarkers are needed to assess present and future toxic effects on Delta species and communities due to present and future water quality conditions in the Delta.

Effectiveness tracking

- Are water quality conditions improving as a result of management actions such that beneficial uses will be met?

- ❖ There is insufficient information to support an answer. However, toxicity testing methods are available that could be used to support effectiveness tracking for management actions that address known problems, such as mitigation of impairments due to organophosphate or pyrethroid pesticides.

- Are loadings changing as a result of management actions?

- ❖ The question does not really apply to toxicity testing. Chemical models are needed to spatially and temporally assess chemical loadings to the Delta and inform the placement of best management practices. Toxicity testing and associated special studies could help focus chemical sampling and modeling on specific chemicals of concern.

Knowledge Gaps

- ❖ More complete coverage of Delta waterways (particularly sloughs and drains) to obtain a more accurate picture of the effects of within-Delta inputs on the Delta ecosystem.

- ❖ Relatively little is known about the actual impacts of potentially toxic constituents on resident Delta species. To accurately assess the impacts of contaminant exposure on Delta species and communities, measures of sublethal effects (including altered behavior, reduced growth, immune system effects, reproductive/endocrine effects, histopathological effects as well as genetic effects) are needed. It will also be important to test a diversity of species (including native species as much as possible), because relying on the traditional species may miss problems (e.g. using cladoceran tests did not reveal the widespread toxicity caused by pyrethroids). Promising approaches are assessments of general fish health condition (Adams et al. 2010) and molecular responses to chemical exposure (Brander 2013).

- ❖ Better linkage between fate and transport of toxicant sources, changes in chemical exposure, toxicity testing, and impacts on organisms and communities in receiving waters. One approach for how this might be done is through modeling approaches that evaluate implications of future chemical use trends and changes in climatic conditions and thus help guide future research and monitoring priorities (Hoogeweg et al. 2011).

- ❖ Development of improved sample collection, analysis, and follow-up methods. While downstream Delta conditions may not change rapidly, test renewal volumes should be representative of actual conditions. Development of in-situ flow-through sample collection and analysis would improve assessments of longer exposure periods.

Evaluation by Decision Criteria

How would monitoring with toxicity testing help to address a significant water quality question?

- ❖ Concerns over toxic impacts on Delta species were the main impetus for developing the RMP. This is reflected in the two original documents calling for the RMP (Central Valley Regional Water Board – Resolution R5-2007-0161 and Bay-Delta Strategic Workplan).

- ❖ Waterbodies in the Delta (e.g., lower Mokelumne River) and on its periphery are listed as impaired for toxicity on the 303(d) list. Spatial and temporal evaluations of aquatic and sediment toxicity within the Delta will address current beneficial use impairments.

How would monitoring with toxicity testing support existing and/or future policy/regulatory programs?

Toxicity data are used to assess whether ambient waters comply with narrative "no toxics in toxic amounts" standards and, thus, whether the goals of the Clean Water Act and the Central Valley Region Basin Plan are met. There are a number of “unknown toxicity” impairment listings within the Central Valley and Delta regions. Future 305(b) assessments would be better supported with a comprehensive ambient toxicity monitoring and science program than through spotty monitoring by various different programs.

How would monitoring with toxicity testing provide a mutual benefit to RMP participants? How would use of toxicity testing attract new stakeholders to participate in funding and/or implementation?

As waterways leading to the Delta and some Delta waterbodies are listed as impaired for toxicity, it is in the interest of all RMP participants to identify the sources of toxicity to (and within) the Delta.

Potential partners with whom there could be a mutual benefit include the IEP, the California Department of Pesticide Regulation (DPR) Surface Water Monitoring Program, Regional Board Surface Water Ambient Monitoring Program, and permitted dischargers:

- ❖ DPR Surface Water Monitoring Program: although DPR currently does not have long-term monitoring sites in the Delta, coordinated toxicity testing would be complementary to chemical data collected by DPR.

- Permitted discharges already collect much ambient toxicity data at a relatively high cost for those programs with little programmatic benefit. The Delta RMP would provide a more appropriate and adaptive science program than NPDES or WDR requirements for development of sample collection, analysis, and follow-up methods.

How could toxicity testing be employed with the pool of available financial and in-kind resources? Is special funding available? What opportunities are there for cost-sharing or leveraging?

- There are potential opportunities for leveraging and in-kind support, for example, through the IEP (sampling, chemical analyses for water quality and nutrients). However, there are no significant opportunities for cost sharing, because NPDES dischargers are the only group of participants that regularly monitors for toxicity, whereas others only conduct special studies (for example, water agencies) or monitor toxicity less consistently (agricultural water quality coalitions).

- Stormwater agencies and agricultural coalitions are required to perform sampling, analysis, and reporting in receiving waters that could be replaced by Delta RMP monitoring.

How would monitoring data provide key input to an important modeling tool?

Simulation models tend to focus on sources, transport, and transformations. Such results for individual constituents may be linked generally to toxic effects on aquatic organisms, but integrating effects of multiple environmental stressors remain beyond the reach of currently available numerical models. However, a better understanding or framework for exposure models may provide more information of the relative importance of specific toxicants without performing costly follow-up TIE work. The two model types could be further developed to better understand the effectiveness of control measures.

What are the technical challenges to monitoring this constituent?

- Standardizing methods for newer species that are more appropriate for future chemicals.

- Interpretation of ambiguous or conflicting results to get an accurate assessment of causation, effects, and corrective actions for complex ecological systems.

Why is it timely to address this constituent?

As was demonstrated when organophosphate use declined and pyrethroid use increased, toxicity testing can identify effects of new contaminants that are either not monitored or monitored at inadequate frequencies or detection limits or for which toxic effect thresholds have not yet been determined. However, selection of toxicity testing species and methods are equally important in identifying constituents of emerging concern. As ecological effects in rivers have shifted from easily identifiable causes (e.g., dissolved oxygen, organophosphate pesticides, etc.) to cumulative and additive effects of a complex combination of toxicants and conditions, ambient toxicity testing provides added insight. To understand these more nuanced effects, sample collection and toxicity testing innovation is also required and would be better accomplished through a sophisticated, transparent, and collaborative program such as the Delta RMP.

Additional Input

Readiness to Proceed

- A Deltawide aquatic and sediment toxicity assessment (supplemented with aquatic and sediment chemistry analyses) based on any of the testing approaches described in Table 2 could begin as early as the first year of RMP implementation.

- Ditto, special studies using standard tests could begin in the first year, provided that the specific management questions are defined which these special studies are supposed to address.

- Pilot studies employing biomarker assessments of general fish health condition or chemical exposure could begin immediately as proof-of-concept or pilot studies.

- In-situ flow-through systems and assessment approaches for evaluating potential water quality effects on fish due to long-term chemical exposure would need to be developed and tested.

Ancillary Conditions

The majority of ancillary data (e.g. dissolved oxygen, pH, electrical conductivity, temperature, turbidity, NH_4, hardness, and alkalinity) needed to interpret toxicity data are measurements required by the toxicity testing methods. Additional chemical analyses (e.g. pesticides, metals, organic carbon) as well as flow measurements would be beneficial to more fully interpret toxicity results.

Environmental Justice Considerations

[EJ defined at http://www.epa.gov/compliance/environmentaljustice/index.html]

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Contributors

- Debra Denton
- Swee Teh
- Lori Webber
- Stephanie Fong
- Stephen McCord
- Kean Goh
- Cathy Johnson
- Brian Laurenson
- Stephen Clark
- Stella McMillin
- Brock Bernstein

Tables

Table 1. Most commonly used aquatic toxicity test organisms.

Test organism		Relative sensitivities
Fish		
Pimephales promelas (fathead minnow)		Ammonia
Onchorynchus mykiss (rainbow trout)		Ammonia
Invertebrates		
Ceriodaphnia dubia (cladoceran, water flea)		Organophosphate pesticides, metals
Hyalella azteca (amphipod crustacean, scud)		Low levels of pyrethroids, cationic metals, somewhat more sensitive to PAHs than the other invertebrate test species
Chironomus (a genus of non-biting midges in the subfamily Chironominae of the bloodworm family, Chironomidae)		Similar to *Hyalella*, but somewhat more sensitive to organophosphate pesticides and carbamates
Algae		

Pseudokirchneriella subcapitata, formerly known as Selenastrum capricornutum (green alga)		*Herbicides*

Table 2. Toxicity tests that can be applied to freshwater systems.

Test	Strength / weakness	Application
Water Tests		
<u>Acute</u>		
Ceriodaphnia dubia: 96-hour survival	Less costly than chronic test but does not include a sublethal endpoint	NPDES discharge permits/Whole Effluent Toxicity (WET) testing, toxicity reduction programs, toxicity evaluation of ambient waters, elutriate toxicity evaluation
Hyalella azteca: 96-hour survival[1] or 10-day survival	More sensitive to pyrethroids than *Ceriodaphnia*. Tests used in programs as alternative to *Ceriodaphnia*, but have not gone through inter-laboratory comparisons.	Examination of toxicity mitigation efficiency, investigation of toxicological interactions
Pimephales promelas: 96-hour larval survival	Less costly than chronic test but does not include a sublethal endpoint	NPDES discharges into freshwater, effluent testing, toxicity evaluation of ambient waters, aquatic toxicity studies for materials and substances
Oncorhynchus mykiss: 96-hour larval survival	Salmonid alternative to fathead minnow. Performed at cold (12ºC) temperature that is not a reflection of typical Delta conditions	WET method (freshwater), sensitivity studies of rainbow trout to chemical constituents/toxicity comparisons, Maximum Acceptable Toxicant Concentration (MATC) estimations, Water Treatment Plant Class II Inspections
<u>Chronic</u>		
Ceriodaphnia dubia: short-term chronic, 6-8 day survival and reproduction	More expensive than acute test	Assessments of effluents, porewater, ambient waters, stormwater, and effects of chemical constituents or mixtures;

		Natural Resource Damage Assessments (NRDA)
Pimephales promelas: 7-day larval survival and growth	More expensive than acute test. Less sensitive to many toxicants than invertebrates.	Effluents, leachates, sediments, ambient waters, elutriates, porewater; effects of materials and substances
Pseudokirchneriella subcapitata: 96-hr growth	Ammonia retards growth but other nutrients stimulate.	Ecotoxicity values for test substances, aqueous environmental samples
Sediment Tests		
Hyalella azteca: acute, 10-day survival and growth	Commonly used, less sensitive than 28-day and 42-day tests but less problematic and costly	Tier 3 biological testing of dredged material, sediment quality surveys, ecological effects of pesticides and toxic substances, evaluation of the predictive ability of sediment quality guidelines (SQGs)
Chironomus: 10-day survival and growth	Standardized EPA and ISO method; does not add much in sensitivity if used in combination with *Hyallela*	Evaluation of harbor sediments, ecological risk assessments, ecological effects of chemical constituents, Tier 3 biological testing of dredged material, evaluation of the predictive ability of sediment quality guidelines (SQGs)
Ceriodaphnia dubia: short-term chronic, 7 day	Conducted at sediment/ water interface, more sensitive to metals than other two tests; *Hyallela/Ceriodaphnia* combined would be a more sensitive 2-species testing system compared to *Hyallela/Chironomus* detecting a broader range of toxicants; not a standardized official method	Bay RMP sediment toxicity (freshwater samples)

1 – Recent studies by Pacific EcoRisk and UC Berkeley have demonstrated that lab populations used for 96-hour *H. azteca* tests may not accurately predict toxicity to resident *H. azteca* (Clark et al. 2012, Weston et al. 2012).

Figures

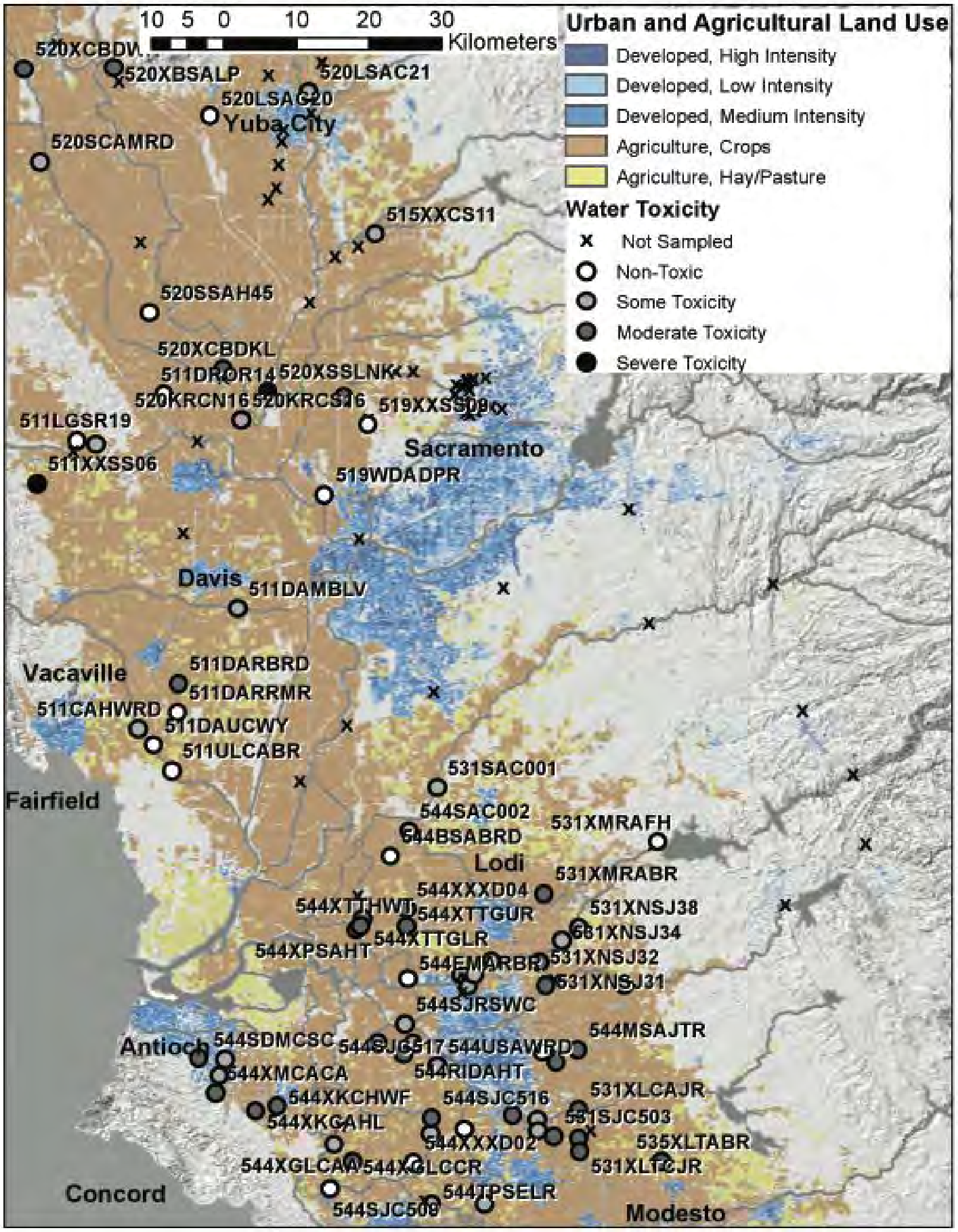

Figure 1. Magnitude of water column toxicity at sites in and upstream of the Delta, based on the most sensitive species (test endpoint) in water samples collected at each site (Markewicz et al. 2012).

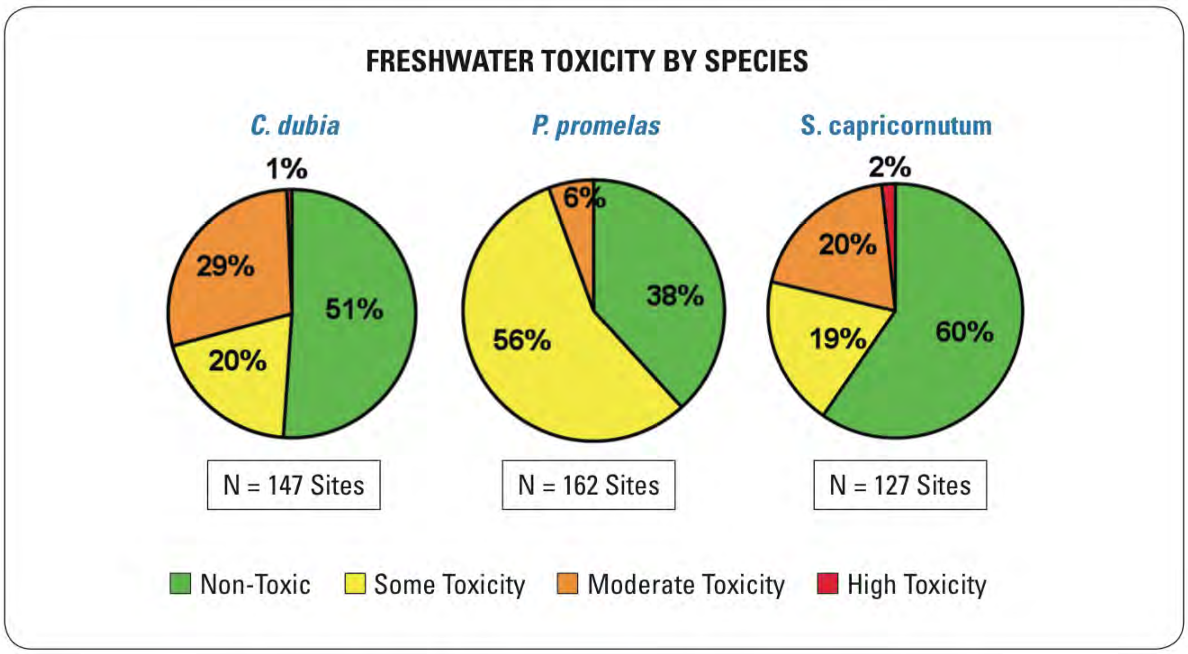

Figure 2. Magnitude of toxicity to individual freshwater species in water samples from the Central Valley region (Markewicz et al. 2012).